The Association Between the Neighbourhood Food Environment and Prevalence of Three Chronic Diseases in Urban Canada: A Cross-Sectional Analysis

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A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science

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Abstract

Research on the association between the neighbourhood food environment and prevalence of chronic diseases is very limited in Canada. The objective of this thesis was to investigate: (i) the associations between the neighbourhood food environment and prevalence of type II diabetes, cardiovascular disease and hypertension among Canadian adults living in urban areas; and (ii) whether or not dietary patterns, obesity and physical activity mediate such associations. Self-reported diagnosis of three chronic diseases, and individual-level socio-demographic and lifestyle variables were taken from the 2009-2010 Canadian Community Health Survey; neighbourhood-level socio-economic data were taken from the 2011 National Household Survey; and the locations of all restaurants and grocery stores in Canada were taken from the 2011 CFM Leads Business Dataset. The associations between prevalence of three chronic diseases and the density of various restaurant and food outlets (density is defined as the number of outlets per 10,000 people and per square kilometer in the respondent's Forward Sortation Area) were analyzed using a modified Poisson regression. The mediation analyses were conducted using the Baron & Kenny method. I found that fast-food restaurant density is positively associated with the prevalence of type II diabetes but statistically non-significant for cardiovascular disease and hypertension. I also find that non-chain restaurants density is negatively associated with the prevalence of type II diabetes. Obesity, fruits & vegetables consumption, and physical activity were found to be partial mediators of these associations. The main implication of this study is that fast-food restaurant density is an important factor for the prevalence of type II diabetes in urban Canada.

Keywords

Food Environment; Chronic Disease; Modified Poisson; Diabetes; Cardiovascular Disease; Hypertension; Baron and Kenny; Mediation

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List of Acronyms

BMI – Body Mass Index

CCHS – Canadian Community Health Survey

CI - Confidence Interval (95%)

DA – Dissemination Area

DAG – Directed Acyclic Graph

EA – Enumeration Area

FSA – Forward Sortation Area

IRR – Incidence Risk Ratio

km^2 – Kilometer squared

PR – Prevalence Ratio

RDC – Research Data Centre

RP – Relative Prevalence

RR – Relative Risk

Chapter 1

1 Introduction

The worldwide rise in the prevalence of chronic diseases is a major health and financial burden faced by governments and their citizens (1). The World Health Organization (WHO) defines chronic diseases as long lasting and slowly progressing conditions that increase in incidence with age and from exposure to certain risk factors (2). Chronic diseases, as opposed to acute conditions, are unique due to their long lasting nature and consequences for poorer health status, reduced quality of life, increased risk of mortality, and higher health care costs. Many of these conditions generally originate through the exposure of multiple risk factors over one's lifetime, ranging from genetic to environmental to behavioural factors (3,4). Although there are many chronic diseases exist, cardiovascular disease, cancer, chronic respiratory disease and type II diabetes are the most prevalent globally (5). WHO estimates show that of the 57 million disease-related deaths in 2011, 36 million were due to non-communicable diseases, with the majority of these deaths being attributed to prevalence of cardiovascular disease (48%), cancer (21%), chronic respiratory disease (12%), and type II diabetes (3%) (2). Some estimates suggest that the treatment of chronic diseases in Canada is about 67% of direct health care expenses, representing C$190 billion annually (6). Thus, prevention and cost-effective management of chronic disease is a major drive for research and policy (7).

Previous research has identified that age (8,9), being male, (10,11), visible minority status (12,13), and lower socioeconomic status and education levels (14–16) have been associated with increased risk of developing chronic diseases. In addition, certain modifiable lifestyle variables, such as physical activity (17–19) and healthy diets (20,21), have been associated with lower risk for chronic diseases. Obesity as a modifiable risk factor presents itself as a unique challenge as it is an outcome of lifestyle choices. Interventions targeting these modifiable lifestyle variables have had very limited success (22,23). Furthermore, research has suggested that these individual level determinants alone cannot truly capture the intricate relationship between the individual level variables and the neighbourhood factors such as the food environment (24,25).

Although several studies have been conducted to assess the relationship between the neighbourhood level food environment and obesity in the literature, limited research exists on the relationship between the neighbourhood level food environment and prevalence of chronic diseases.

The neighbourhood food environment is a result of the complex interaction of multiple variables, ranging from socio-demographic factors to individual preferences. The most commonly used conceptualization of the neighbourhood food environment in the literature was put forth by Glanz *et al.* (26). According to Glanz *et al.* (26), the neighbourhood food environment is a combination of three neighbourhood level factors that influence the eating patterns of individuals: the Organizational Nutritional Environment, the Consumer Nutritional Environment and the Community Nutritional Environment. These factors can then be moderated or mediated by individual-level variables, such as demographic and socioeconomic characteristics. The majority of research to date has focused on the Community Nutritional Environment (27), which can be quantified through a variety of density and proximity based measures (28). Although Glanz *et al.* (26) did not provide a formal definition of the neighbourhood food environment, a definition put forth by Zenk *et al.* (29) is a more function conceptualization. Zenk *et al.* (29) defined the neighbourhood food environment explicitly as “a group of factors including the types of retail food outlets and the availability, quality, and price of different kinds of foods, such as prepared foods, fresh produce, and other groceries, in a given geographical area”, as these characteristics are the most widely used to capture the food environment in the literature.

The neighbourhood food environment is most commonly measured through the availability of different types of food outlets. Healthy food stores generally sell a large variety of foods associated with improved health outcomes, such as fruits & vegetables, lean meats and whole grain products. The consumption of these products have been linked to healthier dietary patterns (30), lower BMI (31,32), lower rates of obesity (33) and reduced risk of chronic diseases (34,35). Unhealthy food stores primarily provide access to calorie dense and low nutritional food options that are high in sugars, fats, and carbohydrates (36). Increased consumption of these types of foods has been associated with a higher intake of energy, fat, sodium, sugar, and sugar-sweetened beverages, as well as lower intake of healthier food alternatives, such as fruits, vegetables, fibre, and milk (37).

Supermarkets and large grocery stores are generally considered healthy food outlets in the literature as these stores offer a large variety of healthy foods at a reduced cost compared to small grocery or convenience stores (38–40). Fast food restaurants, on the other hand, are considered to be one of most important sources of unhealthy foods in the literature as they primarily sell energy dense foods. Not surprisingly, consumption of fast-food has been associated with increased energy and fat intake (41,42), elevating the risk of obesity and weight gain (43–45). Similar to fast-food restaurants, convenience stores are commonly classified as another source of unhealthy foods. Convenience stores typically have a limited amount of space to devote to fruits and vegetables compared to snack foods (46). As a result, these stores mostly sell prepared, high-calorie foods and have limited and expensive fresh produce options (37). Recent literature has also suggested that smaller grocery store are another source of unhealthy foods. Like convenience stores, smaller grocery stores tend to sell energy-dense unhealthy foods and a limited number of healthy foods compared to supermarkets (47).

While fast-food consumption has been associated with poorer diet quality and increased BMI (48,49), the consumption of food from non-fast-food restaurants has been found to have no effect on weight gain (42,50). Studies investigating full-service restaurants have found similar results. Higher vegetable consumption has been reported among adolescents who ate more frequently at full-service restaurants (51), and the availability of full-service restaurants has been associated with a lower risk of obesity and diabetes (52,53). However, other studies found no association between full-service restaurants and weight status (50,54). The effects of medium sized grocery stores are similarly unclear. Most studies have found no association with their density to increased BMI or obesity risk (50,53,55), whereas a few have found small but significant health benefits (44,56).

The relationship between the neighbourhood food environment and chronic diseases remains limited in the Canadian setting. Furthermore, the role of modifiable lifestyle variables, such as physical activity, dietary patterns, and BMI, remains understudied. An understanding of the role these variables play in the casual pathway between the food environment and chronic conditions may provide greater insights.

1.1 Research Objective

The primary objective of this thesis is to examine the association between the neighbourhood food environment and chronic disease prevalence among Canadian adults living in urban areas. Three chronic diseases are considered in this study: type II diabetes, cardiovascular disease, and hypertension. The neighbourhood food environment was captured through the densities of different types of outlets, representing the availability of supermarkets, intermediate sized grocery stores, small grocery stores, fast-food restaurants, full-service restaurants, and local and non-chain restaurants at the Forward Sortation Area (FSA) level. It is hypothesized that greater neighbourhood concentration of healthy food outlets, such as supermarkets, large grocery stores and full-service restaurants, are associated with a reduced prevalence of chronic diseases. Whereas a greater availability of unhealthy food outlets, such as fast-food outlets, convenience stores and small grocery stores, are associated with an increased prevalence of chronic diseases.

The secondary objective of this thesis is to assess the role of three potential mediating variables, dietary patterns, obesity and physical activity, on the casual pathway between the food environment and chronic disease prevalence. It is hypothesized that these variables are potential mediators, serving as intermediary variables in the association between the neighbourhood food environment and prevalence of chronic diseases in Canadian adults.

Chapter 2

2 Literature Review

2.1 Literature Search Strategy

An extensive search was conducted in order to review the literature on the association between the local food environment and chronic diseases. Consistent with the research objective, three chronic conditions (type II diabetes, cardiovascular disease and hypertension) were the main focus of the review. Only studies that included a measure of the local food environment and chronic disease were included. To conduct the literature review, an initial search in PubMed was performed using a combination of the following terms:

"Neighbourhood Food Environment", "Local Food Environment", "Residence Characteristics", "Food Habits", "Food Measures", "Nutritional Environment", "Consumer Environment", "Food Supply", "Restaurant*", "Environment Design*" , and "Food Environment".

Chronic disease was captured using the terms "Chronic disease", "Cardiovas*", "Arterio*", "Myocardia*", "Athero*", "Diabetes", "Diabetes Mellitus", "Diabetes Mell*", "Cholesterol", "Hypertension", "Blood pressure", "Obesity", "Obes*", "BMI", "Body Mass Index", and "Overweight".

The search was limited to articles written in the English language, published between 1990 and 2014. The same strategy was applied with two other search engines: EMBASE and Scopus. Additional references were pulled using Google Scholar and other search engines in order to search for relevant articles, government reports and grey literature. Relevant references available within the biographies of the reviewed articles were further reviewed in order to ensure a comprehensive review of the literature.

A total of twenty relevant studies were identified– 17 cross-sectional and three longitudinal.

2.2 Summary of the Measures of the Food Environment

This section of the literature review will focus on summarizing the different methods used to categorize and measure the local food environment in the reviewed literature.

2.2.1 Definition of Neighbourhood

The definition of the neighbourhood varied greatly between studies (57). The vast majority of the literature used some form of an administrative area as a proxy for neighbourhood. An administrative area is a defined division of a large geographic area, such as a country or province into smaller units for administrative purposes (57,58). Some studies used large administrative areas, such as counties (53,56,59,60) or census tracts (44,61–66), as neighbourhoods while other studies considered US ZIP codes (67) or Forward Sortation Areas (FSA), which are the first three-digits of Canadian postal codes (68). Four studies used unique approaches to describe the geographic scale of their studies. Auchincloss *et al.* (69,70) categorized neighbourhoods as the area within about a 20 minute walk or about a mile from the residence of their study participants. The study by Babey *et al.* (71) defined neighbourhoods using buffers around their participant's home address (with a 0.5 mile buffer used in urban areas, a 1 mile buffer used in smaller cities and suburban areas and a 5 mile buffer used in rural areas). A similar buffer method was used by Naveed (72), where neighbourhoods were determined using three buffers around residential addresses: 0.5 mile, 1 mile, and at 3 mile radius. Three studies, Meyerhoefer & Leibtag (73), Rahkovsky & Gregory (74), and Rashad (75), assessed food price as an exposure measure.

The use of any type of area level proxy to define neighbourhoods, however, can result in spatial aggregation errors. Spatial aggregation errors occur when individual level spatial data are grouped into larger spatial zones, smoothing variation and leading to errors in measurement. Large geographic boundary units are better able to capture stores outside of the immediate food environment around an individual's residence, such as stores encountered on daily travel routes and around potential workplaces. However, due to their large size, these geographic units are more likely to include stores that exist outside an individual's activity space, overestimating their total exposure to food environment (76,77). As a result, recent studies have recommended the use of smaller spatial units, such as Denumeration Areas (DAs) and Enumeration Areas (EAs), as they better capture localized spatial distribution of food availability around an individual's neighbourhood (78). However, the use of small areas to define neighbourhood narrows the scope of the measure, which is referred to as the "local" trap (79). By focusing on the local environment, it excludes the influence of travel behaviors and non-residential places of activity visited on food environment exposure, which is known as an individual's activity space (80,81). Activity spaces are important as a single individual is likely to engage in a variety of activities within a network of commonly visited places that exist outside of their residence, such as schools, work places and commonly traveled routes (81,82). As a result, food stores encountered in these areas may be accessed with greater frequencies due to increased convenience and accessibility while being several miles away from their residential address (79). While measureable though Global Positioning System (GPS), tracking one's activity space is both time intensive and expensive, making it infeasible for large population studies (83).

Defining neighbourhoods through proxies also fails to encompass the influence of bordering neighbourhoods, otherwise known as the edge effect. Individuals residing near administrative borders or in areas with deprived food environments are more likely to access and rely on nearby food stores outside of their immediate neighbourhoods due to increased accessibility. Administrative areas are unlikely to adjust for this, resulting in an underestimation of the total exposure (84). The edge effect has been seen empirically. Sadler *et al.* (85) found that, after buffering neighbouring counties through the spatial analysis to adjust for bordering neighbourhoods, traveling distances to the closest grocery store and fast-food restaurants significantly decreased.

Another method used to define neighbourhoods was through buffers. A buffer consists of an adjustable polygon area around a point of interest, such as a census tract, with the size of the area defining the neighbourhood size (80). Due to their adjustable ranges, buffers are able to provide a more accurate measure of the immediate surrounding food environment (86) and bypass the edge effect, as a buffers radius would be unaffected by neighbourhood borders (85). The scope and size of a buffer can vary based on the study setting and the population of interest (87,88). For example, studies in rural areas are more likely to use larger buffers as individuals travel larger distances to reach food stores (89). Implementing a buffer suitable for an entire study population is difficult due to individual level differences in activity space.

Two types of buffers are currently used in the literature: circular buffers and network buffers. Circular buffers measure the Euclidean, or straight line, distance from a point of interest to local food stores and are most commonly used in the literature (28). Network buffers measure the distance between the initial centroid and final destination through distance travelled in a “network”, ranging from roads to public transportation to pedestrian network paths (27,86). Network buffers are considered to be more robust and representative of the surrounding food environment than circular buffers. While circular buffers are simpler to measure, require less data, time, and expertise to implement, and they are likely to be inaccurate as they do not account for features of the environment that can impede travel and access (88,90), whereas network buffers can (86). These features can be natural, such as rivers, or built, such as railways, bridges, and major highways (90).

2.2.2 Databases

Secondary databases were the most common source of food outlets data. For instance, food outlets data from Canada Business 411 listings (66,68), the US Geological Survey (67), Million Dollar Database (60), InfoUSA (61,63,64,71,72), the US Business database (62) and local and state US government registries (44) were used. Three studies, Holmes & Thompson (59), Ahern *et al.* (56), and Salois (53), used the United States Department of Agriculture (USDA) Food Environment Atlas as a data source. The Food Environment Atlas was constructed by the US Census Bureau through the compilation of data from the Behavioral Risk Factor Surveillance System (BRFSS) survey and US Census data between the years of 2006 to 2008. Adamus-Leach *et al.* (65) was the only study that collected primary data, with the researchers physically confirming food store counts within 12 neighbourhoods in Austin, Texas.

Food price data was taken from the Bureau of Labor Statistics (75) or Nielsen Homescan panel dataset, which compiled and created weighted purchasing frequencies for residential food purchasing patterns on 630 food items on American households within 48 states (73,74).

Secondary databases are most convenient for large scale studies (91), with these databases being compiled with additional food store information for further differentiation between store types (92). Secondary databases, however, are prone to accuracy issues, such as obsolete data and clerical errors (92,93), reducing their reliability (91,94). While primary databases are more accurate (95), compiling these data is time and resource intensive, making them impractical for large scale studies (91). Consequently, public health researchers continue to rely on secondary databases to characterize the retail food environment (54,96–98).

2.2.3 Classification of the Food Environment

Food outlets from secondary databases were categorized using the North American Industry Classification System (NIASC) (44,61,64,71) or Standard Industrial Classification (SIC) codes (60,63,66). Naveed (72) used SIC codes in combination with other restaurant details, such as employee size and annual sales volume, to classify food outlets into meaningful groups. Some studies categorized food outlets by major retail chain names. For example, Alter *et al.* (68) identified fast-food outlets by using the nine leading fast-food chains: McDonalds, KFC, Taco Bell, Wendy’s, Harvey’s, Swiss Chalet, Dairy Queen, Pizza Hut and Burger King. Similarly, Dubowitz *et al.* (64) identified fast-food outlets by using ten leading fast-food restaurant chains, McDonald’s, Subway, Burger King, Taco Bell, Pizza Hut, Little Caesars, KFC, Wendy’s, Domino’s Pizza and Jack in the Box. Li *et al.* (63) and Babey *et al.* (71) used similar approaches.

By limiting food stores to major chain locations, researchers are able to accurately identify and classify food outlets because chained stores provide similar goods and services regardless of location and are easily accessible through retail directories. However, using only major chain locations excludes local and non-chained food outlets, which comprise the largest portion of available outlets. These local stores may exert a greater influence on the food environment as they are accessed more frequently.

Some studies categorized food stores using defined traits and properties. However, a great deal of variation in the definition of traits across studies was found. Morgenstern *et al.* (62) classified a fast-food restaurant from the US Business database if the location had two or more of the following qualities: expiated food service, takeout business, limited or no wait staff, and customers who pay prior to receiving food. Daniel *et al.* (66) used two independent raters to classify fast-food restaurants chains and non-chains based on their capacity to sell predominately high-caloric foods, including hamburgers, fries or poutine, and soft drinks. Babey *et al.* (71) defined fast-food restaurants using the National Restaurant Association distinction between “table service” and “quick service (fast-food)” locations: counter service, by meal service (vs. snacks, dessert, and coffee) and lower prices (less than $7/meal). Major chains were further identified if the restaurants had five or more locations with the same name and provided counter-service meals at these locations. A similar methodology was used in two papers by Holland *et al.* (99,100) , which defined fast-food chain restaurants as restaurants in which the food is ordered and paid for before eating or taking out and full-service restaurants as restaurants in which the customers is served food and then pays after eating.

2.2.4 Types of Measures

Two types of measures were predominately used to quantify the availability of food outlets: counts and densities (27). Counts quantify the food environment through measuring the total number of food locations within a defined neighbourhood, such as the total number of locations within a FSA or buffer area (27,28). While very simple to calculate and apply in practice, counts fail to adjust for the population level and geographic properties of the neighbourhoods (80). Density measures adjust for neighbourhood population, representing the concentration of different food outlets (28,80,86). Density measures are usually defined through population size, measured as the number of locations within the defined area per 1,000 or 10,000 individuals (27). Another way to define density is through the number of food stores per square kilometer. The issue of extreme values, due to large rural areas with limited food stores and small highly developed urban neighbourhoods could be problematic as it can lead to inflated estimates of availability (80,86). Thus, some studies suggested controlling for population density to account for potential biases (101,102).

The majority of papers used population weighted density measures, ranging from the density of food outlets per 1000 people (53,56,64,67) to 100,000 people (68). Li *et al.* (63) and Daniel *et al.* (66) used geographically weighted measures of density, evaluating the amount of food outlets per square mile and per square kilometre respectively. Stewart *et al.* (60), on the other hand, used per capita rates of food stores, but the level of geography at which these measures were constructed were not provided. Brown *et al.* (61) used a unique geographic approach, measuring density through road network analysis as the number of stores per roadway mile. Brown *et al.* (61) rationalized its use due to its ability to account for the effect of large, undeveloped geographic areas and travel routes, providing a more accurate measure of accessibility to food stores in urban areas. Three of the reviewed studies (44,62,65) measured food availability through counts, defined as the total number of food store locations in the surrounding neighbourhood. Morland *et al.* (44) measured availability as the absence or presence of the respective food store type within each census tract, dichotomizing the area level counts of each food store into these 2 categories.

An alternative method of measuring density was through buffers. Four of the reviewed papers used some type of buffer in their analysis (62,64,72). This approach, however, was used by only one Canadian study by Daniel *et al.* (66); which used a buffer of 1 km radius around each census tract in order to measure availability. The researchers rationalized the use of a 1 km buffer as it was representative of a 12 minute walking distance outside of each census tract boundary, adjusting their measures for variations in activity space and the edge effect.

Another common measure of density was through the Economic Research Service Food Environment Atlas (56,59). These density measures were calculated at the US county level and weighted using population counts, with available measures being calculated as the number of locations per 1,000, 10,000, or 100,000 residents within each US County. Data was gathered using the Behavioral Risk Factor Surveillance System (BRFSS) survey and the US Census data and complied by the US Census Bureau. The overall quality food environment was assessed using an index called the Retail Food Environment Index (RFEI) (71). The RFEI was calculated as a ratio of unhealthy food stores, defined as convenience stores and fast-food restaurants, to healthy food stores, which include supermarkets and large grocery stores, within a given buffer area. The RFEI, however, used a very restrictive definition of unhealthy and healthy stores in order to create their index, which underestimates total exposure to the food environment.

Two methods of measuring food price were used in order to assess the food environment (73–75). Rashad (75) assessed food price as the average cost of foods after they had been grouped into 2 broad categories: foods that increased glycosylated hemoglobin (HbA1c) levels and foods that decreased HbA1c levels. Both Meyerhoefer & Leibtag (73) and Rahkovsky & Gregory (74) used the Nielsen Homescan panel dataset, which provided weighted averages on purchasing and price data, as their source of food price data. Meyerhoefer & Leibtag (73), however, categorized food price data in 4 food groups based on nutritional content, whereas Rahkovsky & Gregory (74) grouped their food price into 14 groups based on food type.

Two studies measured the food environment as the perceived availability to healthy food resource in the surrounding neighbourhood (69,70). It was derived from the Community Study subsection of the Multi-Ethnic Study of Atherosclerosis (MESA) Neighbourhood Study. The survey posed a set of following 3 statements, marked through a 5 point scale, to estimate the overall perceived neighbourhood availability of healthy food within 3 American counties: “A large selection of fresh fruits and vegetables are available in my neighbourhood", "The fresh fruits and vegetables in my neighbourhood are of high quality", and "A large selection of low-fat foods are available in my neighbourhood".

Two papers assessed a measure of accessibility: Ahern *et al.* (56) and Salois (53). Both papers assessed accessibility through the percentage of households with no cars that lived more than 1 mile away from a grocery store, available through the Food Environment Atlas.

Proximity to food outlets was also used as a measure of the food environment. Proximity is a measure of accessibility, defined as the distance from a point of interest or centriod to the closest food store (28,80). It can be derived through buffers, measured as either Euclidean distance or network distance. As pointed out earlier network analysis is preferred as it can most efficiently measure the shortest distance from the centroid to the destination. While the distances obtained through proximity measures can provide another means of categorizing the food environment, they are unable to provide context to distances. For example, distance travelled can vary due to neighbourhood size and development, access to transportation services, and the mode of transportation, factors that most distance based measures do not adjust for (28,80,86). Some studies have measured proximity as the estimated travel time along a network path. Travel time estimates, however, are difficult to acquire and calculate, limiting their use in the existing literature (28).

2.3 Review of the Food Environment and Chronic Disease

The association between the neighbourhood food environment and prevalence of major chronic diseases found in the literature are presented in the following two sections. The review of the literature is divided into 4 sub-sections focusing on the major chronic diseases: type II diabetes, hypertension, cardiovascular disease, and high cholesterol.

2.3.1 Type II Diabetes

2.3.1.1 Density of Food Outlets and Type II Diabetes

Five studies assessed the association between the density of various food outlets and type II diabetes. Ahern *et al.* (56) and Salois (53) analyzed the association between the measures of food environment and prevalence of type II diabetes at the county level in the United States. Both studies used the Food Environment Atlas and used the number of food stores per 1000 people at the county level. Diabetes prevalence rates were defined as the age adjusted prevalence of adult diabetes per 100 individuals in each county.

Salois (53) found that the density of fast-food restaurants (p=0.01), gas-based convenience stores (p=0.1), and non-gas-based convenience stores (p=0.01) were positively associated with higher diabetes prevalence. The density of full-service restaurants (p=0.01) and farmer's markets (p=0.05), however, were negatively associated with diabetes prevalence (p=0.01). The density of supercenters, warehouse club stores, grocery stores and supermarket stores were not statistically significant predictor of diabetes prevalence. The null results for supermarkets and grocery stores may be due to researchers combining these outlets into a single measure, as small grocery stores have less variety and more expensive healthy produce compared to supermarkets.

Ahern *et al.* (56) found results similar to Salois (53), with concentration of convenience stores and fast-food restaurants being associated with higher mortality and prevalence of obesity. The availability of grocery stores and supermarkets, however, were associated with reduced mortality and obesity. County rates of diabetes prevalence were found to increase by 0.41 % per one outlet increase in the availability of fast-food restaurants and by 0.30 % per one outlet increase in the availability of convenience stores per 1000 individuals (p<0.001). Like Salois (53), Ahern *et al.* (56) found diabetes prevalence rates decreasing by 0.15 % per one outlet increase in the density of full-service restaurants. They also found that a one unit increase in the density of grocery stores was associated with a 0.37% decrease in diabetes prevalence (p<0.01). By contrast, Salois (53) found no association between grocery store density and diabetes prevalence (p>0.05) .

In terms of accessibility, Salois (53) found that decreasing accessibility was associated with an increase in obesity, however no significant association was found with the prevalence of diabetes. Ahern *et al.* (56), however, found that increasing accessibility was significantly associated with greater diabetes rates, with diabetes prevalence increasing by 0.07 per grocery store within a 1 mile radius of residence ($p < 0.01$). This association was seen in both rural and urban areas, with rates increasing by 0.1 per grocery store and by 0.07 per grocery store within a 1 mile radius of residence, respectively. Limited accessibility to food outlets can be the result of transportation difficulties, such as not owning a car or poor access to public transportation, but can also be the result of an inadequate supply of food outlets selling nutritious food.

A key strength of these two papers was the use of both healthy and unhealthy food stores in their analysis. Both studies also adjusted their analysis for the potential effects of BMI and obesity, an important confounder in the casual pathway for chronic disease development. However, the analyses in both papers were conducted at the county level, a very large administrative area that may not be representative of the local food environment. Furthermore, both studies focused solely on neighbourhood level measures and covariates, reducing the ability to draw individual level conclusions.

Morland *et al.* (44) examined the association between the neighbourhood food environment and the prevalence of multiple cardiovascular disease risk factors, one of which was type II diabetes. Diabetes prevalence was confirmed through researcher verified diagnosis, with diabetes being diagnosed if glucose levels were greater 200 mg/dL, 8-hour fasting glucose levels were above 126 mg/dL, and/or the study participants were taking any glucose managing medication. The food environment was assessed as a dichotomous measure, measured as the absence or presence of each of the assessed food outlets at the census tract level. A positive association was observed between the presence of grocery stores and type II diabetes prevalence, with a 34% and a 33% increase in prevalence rates being seen in the unadjusted model and the model adjusted for the presence of other food stores. However, this association was attenuated when the model was further adjusted for socio-demographic variables. Furthermore, no associations were found between the presence of supermarkets and convenience stores and prevalence of diabetes. However, Morland *et al.* (44) did not assess the effects of fast-food restaurants. Furthermore, the researchers limited their analysis to solely the presence and absence of food outlets within each census tract. While this measure may be useful for assessing the access to healthy food outlets like supermarkets, it may fail to accurately capture the exposure to more abundant unhealthy outlets, such as convenience stores and smaller grocery stores.

Stewart *et al.* (60) examined the efficacy of ring maps in multivariable regressions with regards to population health, including diabetes prevalence, and environmental variables, including the number of fast-food restaurants and convenience stores per capita, in Caucasian and African American adults. The county level per capita fast-food restaurants and convenience stores were calculated using 2008 county population estimates and SIC codes. Age standardized diabetes prevalence was ascertained using ICD-9 codes from the South Carolina Medicaid database between July 2009 and June 2010. Stewart *et al.* (60) found that age adjusted diabetes prevalence was not significantly associated with either fast-food restaurants per capita (Odds Ratio=0.40; p=0.140) or convenience store per capita (Odds Ratio=1.50; p=0.526) in their bivariate analysis. However, Stewart *et al.* (60), did not differentiate between type I and type II diabetes and their study population was restricted to African American Medicaid recipients. Since these associations were only tested for in the African American population Medicaid recipients, the finding cannot be generalized to the general population. Food stores were categorized into groups from a secondary database using SIC codes as well, a method of classification that has been shown to have errors (94,103).

Holmes & Thompson (59) examined the correlation between food availability and the prevalence of diabetes and obesity in Ohio food deserts. Food availability was calculated from 2008 Census tract data, the USDA Food Environment Atlas, and the USDA Food Desert Locator. Six food store measures were used in this study: grocery stores per 100,000 individuals, supercenters and club store per 100,000 individuals, fast-food restaurants per 100,000 individuals, farmers markets per 100,000 individuals, convenience stores with no gas station per 100,000 individuals, and convenience stores with gas station per 100,000 individuals. Diabetes and obesity prevalence rates were calculated by the Centre for Disease Control and Prevention (CDC) using age adjusted percentages from the 2007-2009 BRFSS database. Holmes & Thompson (59) found that the number of supercenters and club stores (Effect Size: 25; $p<0.01$) and the number of convenience stores with (Effect Size: 15; $p<0.05$) and without gas station (Effect Size: 17; $p<0.01$) were positively correlated with type II diabetes, while the number of grocery stores (Effect Size:-12; $p<0.05$) and fast-food restaurants per 100,000 people (Effect Size:-33; $p<0.01$) were negatively correlated with the diabetes prevalence. Farmer's markets were found to be statistically non-significant with diabetes prevalence ($p>0.05$). These results were similar to the studies by Salois (53) and Ahern *et al.* (56) discussed earlier, both who used the Food Environment Atlas.

2.3.1.2 Summary of Findings

Of the five papers that assessed the association between the availability of food outlets and type II diabetes prevalence, four studies found statistically significant positive associations. In terms of healthy food stores, supermarket and grocery store availability were grouped together and assessed in three studies. Two studies, Ahern *et al.* (56) and Holmes & Thompson (59), found a negative association (56) and correlation (59) with diabetes prevalence. The third study, by Salois (53), found statistically non-significant results. As all three studies used the USDA Food Environment Atlas data, differences in their findings are likely due to the adjustments made in the study population and the inclusion of varying measures and confounders in their analysis. For example, Ahern *et al.* (56) did not include convenience stores without gas station and wholesale supercenters while Salois (53) excluded lifestyle variables, such as obesity and smoking status, from their analysis. Morland *et al.* (44), on the other hand, assessed supermarket and grocery store availability separately. The researchers found that grocery store availability was positively associated with diabetes while supermarket availability was statistically non-significant, suggesting that grocery stores and supermarkets may need to be assessed separately. Farmer's markets were also found to be negatively associated with diabetes prevalence by Salois (53), however Holmes &Thompson (59) found statistically non-significant associations (59).

The associations found between fast-food restaurant availability and diabetes prevalence were mixed. Out of four studies, only two found positive associations (53,56), while one discovered a negative association (59) and the other a non-significant association (60). Full-service restaurants, however, displayed an opposite trend, with Ahern *et al.* (56) and Salois (53) both finding that full-service restaurants were negatively associated with diabetes prevalence.

In terms of other food stores, convenience stores were mostly positively associated with diabetes rates, with three out of five studies (53,56,59) finding positive associations while the two remaining studies (44,60), Morland *et al.* and Stewart *et al.*, found statistically non-significant associations. Gas stations (53,59) and wholesale retailers and supercenters (59) were also found to be positively associated with diabetes prevalence, although these food outlets were not typically assessed as measures of food environment in other studies.

2.3.1.3 Food Price and Diabetes

Only two papers assessed the association between food price and diabetes prevalence. Rashad (75) assessed the association between the price of foods with high and low glycemic indices and type II diabetes. Rashad (75) measured blood glucose levels using glycosylated hemoglobin levels (HbA1c). Food price was measured through two categories: a high glycemic index (GI) group, which contained foods that increased HbA1c levels, and a low GI group, which contained food that decreased HbA1c levels. The researcher found that higher price of high GI foods was associated with lower blood glucose levels, while higher price of low GI foods were associated with higher blood glucose levels, although the results were not significant ($p>0.10$). Rashad's (75) use of HbA1c levels to measure blood glucose provided a more accurate assessment of blood glucose as it was less susceptible to daily fluctuations in blood sugar. Only a limited number of food types were used to create the glycemic index groups, however, reducing the external validity the exposure measure.

Meyerhoefer & Leibtag (73) investigated the association between changes in the relative price of low and high carbohydrate foods and diabetes related expenditure, diabetes prevalence, and total medical expenditure. Different food types and prices were obtained through 2000-2005 Nielsen Homescan panel dataset and were classified into four groups based on nutritious content: low carbohydrates, low/medium carbohydrates, medium/high carbohydrates, and high carbohydrates foods. Diabetes prevalence rates and expenditures were obtained through the Medical Expenditure Panel Survey (MEPS), which identified cases using the International Classification of Diseases 9 (ICD-9) codes 49 and 50. Meyerhoefer & Leibtag (73) found no statistically significant association between the prevalence of diabetes and the price of any of the carbohydrate food groups ($p>0.10$). While the study did use individual level weighted food data, it did not adjust for food eaten away from home and diets altered by medical treatment, which could alter food frequency weighting and food price data.

2.3.1.4 Summary of Findings

Both Rashad (75) and Meyerhoefer & Leibtag (73) found statistically non-significant associations between food price and diabetes in the US.

2.3.2 High Blood Pressure and Hypertension

Two papers assessed the association between the neighbourhood food environment and hypertension prevalence (Dubowitz *et al.* (64) and Morland *et al.* (44)). Both studies were conducted in the US using a cross-sectional study design.

Dubowitz *et al.* (64) examined the association between high blood pressure and the availability of supermarket and grocery stores and fast-food restaurants. Systolic and diastolic blood pressure measures were collected through the Women's Health Initiative Clinical Trial. Hypertension was diagnosed if systolic blood pressure was greater than 140 mmHg or diastolic blood pressure was greater than 90 mmHg. Through logistic regression, Dubowitz *et al.* (64) found that the availability of fast-food restaurants was not associated with DBP, SBP, and hypertension ($p>0.05$). However, the density of grocery stores and supermarkets was negatively associated with DBP ($\beta= -0.162$, $P< 0.01$), with a 0.31 mmHg drop in DBP being seen between the 10th and 90th percentiles. Furthermore, a significant inverse association between the availability of supermarkets and grocery stores and hypertension prevalence (OR = 0.97; $P < 0.05$) was found. The negative association between hypertension and supermarket density could be due to the study population, with post-menopausal women having higher rates of blood pressure than their pre-menopausal counterparts, limiting external validity (104). Furthermore, only a limited number of food outlets were assessed. Supermarket and grocery store availability was constructed using NAISC codes, which may have introduced misclassification error. Fast-food restaurant availability was constructed by identifying the top 10 major fast-food retail chains, excluding smaller chain and local restaurant locations.

Morland *et al.* (44) also found similar associations between the prevalence of hypertension and the food environment. Hypertension was diagnosed if systolic blood pressure levels were greater than 140 mmHg or if diastolic blood pressure levels were greater than 90 mmHg, with blood pressure measurements being collected from 1993 to 1995. All food stores were assessed as either the absence or presence of each respective location type at the census tract level. The researchers found a 12 % decrease in the prevalence of hypertension within areas that had at least 1 supermarket compared to those that did not. The opposite effect was seen for the presence of grocery stores and convenience stores. The presence of grocery stores and convenience stores resulted in a 20 % and 12% increase in hypertension prevalence, respectively, compared to the areas in which these stores were absent. However, these observed associations disappear after adjusting for the presence of other stores and socio-demographic variables. Only the association between hypertension and supermarket availability remained statistically significant.

Two studies assessed the association between the food environment and changes in blood pressure (BP) (Li *et al.* (63) and Adamus-Leach *et al.* (65)).

The study by Li *et al.* (63) assessed the longitudinal change in SBP and DBP due to the food environment over a one year period in older adults. The researchers collected resting blood pressure measurements over a one year period; mean change in values for systolic and diastolic blood pressure were their outcome. The density of fast-food restaurants was constructed using SIC codes. Participants were divided into two groups: high density (if fast-food restaurant density was in 75th percentile and higher), and low density (if fast-food restaurant density was in 25th percentile and lower). After controlling for neighbourhood level walkability and individual level covariates, Li *et al.* (63) found that living in areas with a higher density of fast-food restaurants were predictive of an increase in systolic (β=5.32, P<0.001) and diastolic (β=2.21, P<0.001) blood pressure when compared to areas with lower fast-food density. This was the only longitudinal study showing the link between fast-food density and increased blood pressure levels. However, the short time frame of the study limits the ability to capture the incidence of hypertension. Furthermore, the researchers assessed only a single measure of the food environment.

Adamus-Leach *et al.* (65) examined if neighbourhood income moderated the association between fast-food restaurants or supermarket availability and health related outcomes in 12 public housing neighbourhoods in Houston, Texas. The food environment was captured as the count of the fast-food restaurants and supermarkets within each neighbourhood. Measurements of resting blood pressure were collected from 213 residents by the researchers. Bivariate correlation analysis showed that fast-food restaurant (r=0.134, p<0.05) and supermarket (r=0.243, p<0.01) availability were both correlated with increased systolic blood pressure, while only fast-food availability was associated with increased diastolic blood pressure (r=0.146, p<0.05). However, after adjusting for age and gender, the correlations between both fast-food restaurant and supermarket availability and blood pressure were attenuated (p>0.05). One important limitation of this study was that only 12 low income neighbourhoods within southern Texas were used, limiting the generalizability of the results.

2.3.2.1 Summary of Findings

In summary, significant associations with hypertension prevalence were observed in the literature. Whereas Dubowitz *et al.* (64) assessed supermarkets and grocery stores exposure as a single density measure and found a negative association, Morland *et al.* (44) assessed them separately, finding a negative association between supermarket density and hypertension prevalence and a positive association between grocery store density and hypertension. This suggests that a separation of supermarkets and grocery stores availability is needed to properly assess their respective associations. A similar negative association was seen with convenience store density by Morland *et al.* (44), although this association was attenuated after adjusting for sociodemographic confounders. Dubowitz *et al.* (64) was the only study to examine the association between fast-food availability and hypertension prevalence, but no significant associations were found. Adamus-Leach *et al.* (65) also found that increasing supermarket density was correlated with increased SBP levels; however this association was attenuated after adjusting for possible confounders. In terms of unhealthy food stores, Adamus-Leach *et al.* (65) found a positive correlation between fast-food density and increasing SBP and DBP levels. Similarly, Li *et al.* (63) found that fast-food restaurant density was predictive of increasing SBP and DBP over time.

2.3.3 High Cholesterol

Morland *et al.* (44) assessed the association between the neighbourhood food environment and cholesterol levels. Cholesterol levels were measured as the total serum cholesterol level per individual. High cholesterol was defined as total serum levels >200 mg/dL and/or the respondent reported taking cholesterol-lowering medication in the past two weeks. Food environment was assessed in terms of absence of different food stores within each neighbourhood. No statistically significant associations were found between the availability of supermarkets, convenience stores, or grocery stores and high cholesterol in both their unadjusted and adjusted analysis.

A study conducted by Rahkovsky & Gregory (74) examined whether changes in food prices were related to changes in cholesterol levels. Food price was collected through the Quarterly Food At Homes Price Database (QFAHPD), which was derived through the Nielsen Homescan panel dataset. The data were then further aggregated into 14 categories based on their nutritional content. Non-high density lipid cholesterol (non-HDL) data was calculated through subtracting the High Density Lipids (HDL) cholesterol from Total Density cholesterol from the National Health and Nutrition Examination

Survey (NHANES). The researchers found that a 10 % increase in the price of processed foods and refined grains was associated with an average decrease of 15.7 mg/dL and 6.4 mg/dL in HDL levels, while a 10% increase in vegetable and whole grain prices was associated with an increase of 19.4 mg/dL and 13 mg/dL in non-HDL levels. In addition, a 10% increase in the prices of processed foods and whole milk products was associated with a decrease of 34.5 mg/dL and 12.2 mg/dL in HDL levels. A key limitation of the study was that the QFAHPD did not measure and adjust for possible food purchasing outside of the home, or diets altered due to medical conditions or financial restraints through welfare/food stamp programs.

2.3.3.1 Summary of Findings

Morland *et al.* (44) assessed the availability of the food stores while Rahkovsky & Gregory (74) assessed food price, thereby limiting the comparability of the findings. In summary, Morland *et al.* (44) found no association between the food stores and the prevalence of high cholesterol, while Rahkovsky & Gregory (74) found that the price of vegetables was positively associated with non-HDL cholesterol levels.

2.3.4 Cardiovascular Disease

Only three papers assessed the associations between the food environment and cardiovascular disease. Two papers were conducted in Canada using cross sectional designs.

Alter & Eny (68) examined the association between the incidence of acute cardiovascular syndromes hospitalization and the availability of fast-food restaurants. Cardiovascular disease incidence was obtained using a combination of hospital admission information from Canadian Institute of Health Information (CIHI) and International Classification of Diseases (ICD) 9 codes. Fast-food restaurant availability, calculated at the FSA level, was categorized into 3 groups or tertiles based on their density of fast-food locations: low: 0-9.5, average: 9.6-19.2, and high: >19.3. Alter & Eny (68) found that FSAs with greater density of fast-food locations had significantly larger odds of mortality and acute coronary syndromes, with an increase of 152% in the odds of overall mortality and a 126% increase in the odds of acute coronary syndromes being seen when comparing FSAs in the lowest and highest density tertiles. These results were still significant after adjusting for all relevant confounders (OR=2.26 $P<0.001$). Furthermore, the researchers found that an increase of one fast-food outlet per 100,000 individuals per FSA was associated with an additional one death per 100,000 persons due to cardiovascular disease ($p<0.001$). No significant differences were found when fast-food density was analyzed as a continuous variable instead of tertiles. The use of incidence rates of cardiovascular syndromes was unique to this study, with most papers using prevalence of chronic disease as the outcome measure. However, Alter & Eny (68) used a very limited definition of fast-food restaurants, restricting their groups to only the top 9 major retail chains based on market shares and excluded other major chains and local non-chain restaurants.

The second Canadian based study, conducted by Daniel *et al.* (66), assessed the association between cardiovascular disease related mortality and density of fast-food restaurants and fruits & vegetables stores in Montreal, Canada. Cardiovascular disease related mortality was identified through a combination of the Quebec Ministry of Health and Social Services database and ICD-9 and ICD-10 codes. Density was calculated in Montreal Census Metropolitan Area (MCMA). Fruits & vegetables stores were identified using a combination of SIC codes and major retail chains and fast-food restaurants were collected through manual data collection and categorization by 2 independent raters. Multivariable analysis found that there was a significant positive association between fast-food restaurant density and rates of cardiovascular (CVD) and non-cardiovascular (non CVD) related mortality. A 10% increase in fast-food restaurant density was found to be associated with an increase of 39% (95% CI= 1.19-1.63) and 36 % (95% CI= 1.18-1.57) in the relative risk of death from CVD and non CVD causes, respectively. Fruits & vegetables store density was found to be not significantly associated with both cardiovascular and non-cardiovascular related mortality ($P> 0.17$). A key strength of this study was the use of a clear categorization of both fast-food restaurants and fruits & vegetables stores, increasing the internal validity of the exposure measures. However, increased rates mortality were seen for both cardiovascular disease and non-cardiovascular disease related causes of death, suggesting that the food environment may be associated with overall mortality rather than simply cardiovascular mortality.

Naveed (72) assessed the association between access to food stores and the incidence of myocardial infarction in post-menopausal women in San Diego County. The incidence of myocardial infarction was found using a combination of self-reported cases and medical records using ICD-9 codes. Food stores were classified using a combination of SIC codes, employee size and annual sales volume into four groups: grocery stores, convenience, limited service facilities and restaurants. Using a Cox Proportional Hazard model, Naveed (72) found that the number of grocery stores in a ½ mile buffer around the participants' residence was associated with a 17.4% increase in the risk of myocardial infraction, while the number of restaurants increased the risk of myocardial infarction by 18.2% in a ½ mile buffer and by 15.5% in a 1 mile buffer around the study participants residence. The number of convenience stores found an opposite association -- the risk for a myocardial infarction event associated with a 39% decrease in a 1 mile buffer around the participants' residential address. Although the longitudinal design is a key strength of this study, the study's sample was limited to less than 200 post-menopausal women, thus limiting the generalizability of the results.

2.3.4.1 Summary of Findings

The results of Alter & Eny (68) and Daniel *et al.* (66) were similar, with both studies finding that fast-food availability was positively associated with cardiovascular disease mortality. Daniel *et al.* (66) also found that fruits & vegetables store availability was not associated with cardiovascular related mortality. However, Naveed (72) found a positive association between supermarkets availability and the prevalence of cardiovascular disease in the US. These differences in results may be due to Daniel *et al.* (66) using a mortality related outcome rather than prevalence or incidence as used by Naveed (72). Naveed (72) also found that the total number of restaurants in the neighbourhood was associated with an increased risk of myocardial infarction while the association with respect to the number of convenience store was in the opposite direction.

2.4 Potential Mediators

Existing literature on the role of potential mediators in the casual pathway between the food environment and health outcomes is limited. Of the reviewed studies, only Auchnicloss *et al.* (69) and Dubowitz *et al.* (64) conducted some type of mediation analysis.

Auchnicloss *et al.* (69) examined the role of BMI, physical activity, and dietary patterns as potential mediators when examining the association between the perceived availability of food stores and insulin resistance. Their analysis suggested that all three variables are partial mediators, with a 5% increase in the difference between the prevalence of impaired fasting glucose being observed after adjusting their model for physical activity and dietary patterns. A further 12% increase in the total effect size was further seen after adjusting for BMI. Although no formal method of testing for mediation was employed, a test for the attenuation of effect size was use to examine the mediating role of these variables.

Dubowitz *et al.* (64), however, found limited evidence of physical activity mediating the association between hypertension and the availability of fast-food. Although physical activity was found to be both negatively associated with obesity and hypertension, limited attenuation was observed in the regression coefficient after adjusting for physical activity. Like Auchincloss *et al.* (69), no formal mediation analyses was conducted.

Within the realm of the built environment, mediation has been assessed in a few studies (105). A study by Dyck *et al.* (106) found that physical activity was a mediator in the association between neighbourhood walkability and BMI. The study used bootstrap analysis (106) in order to assess for mediation, with a between-neighborhood difference of -0.11 kg/m^2 in BMI being found between residents of high versus low walkable neighborhoods due to engaging in moderate-to-vigorous physical activity. Similar results were found by Mujahid *et al.* (107), with an individual's diet and physical activity mediating the association between neighborhood physical environments and BMI. The researchers used the Baron and Kenny approach for mediation analysis, with a significant attenuation in the mean change in BMI being observed. The mean change in BMI decreased from -1.06 to -0.69 in women, and from -0.73 to - 0.44 in men after adjusting for age, race/ethnicity, income, education level, as well as total energy intake, AHEI, and physical activity (107). Many studies, however, instead assessed the role of perception of the environment and food preference in the causal pathway (32,108–110), which has limited applicability within the context of this thesis as it is out of the scope of the conceptual model.

The following three sub-sections discuss the potential mediating role of BMI, dietary pattern, and physical activity in the relationship between the food environment and chronic disease.

2.4.1 Dietary Patterns

2.4.1.1 Dietary Patterns and Food Environment

The food environment influences dietary patterns through altering the availability and consumption of healthy and unhealthy food products. Recent reviews of the literature have found that increased availability of healthy food stores are associated with healthier dietary patterns (37). Food outlets, such as supermarkets, provide a large variety of fruits, vegetables and healthy food products at relatively lower costs compared to other types of food outlets (111–113). Consequently, residing near these locations increases the availability and access to healthier food products, leading to healthier diets and food intake, an association that has been found in the literature. For example, Larson *et al* (37) found that better access to supermarkets was associated with having healthier diets and Rose *et al.* (114) found that easy access to supermarkets is associated with increased consumption of fruits, while increasing distance from home to food stores was inversely associated with fruits & vegetables intake. Furthermore, Bodor et al (115) found that greater fresh vegetable availability within 100 m of residence was a positive predictor of vegetable intake. Similarly, the absence of supermarket availability and other healthy food stores has also been associated with reduced access to and consumption of fruits &

vegetables (97,116,117), resulting in poor health outcomes. Laraia *et al.* (30) found that women living greater than 4 miles from a supermarket increased the odds of poorer overall dietary quality by 2.16 (95% CI: 1.2- 4.0) compared to those living within 2 miles of a supermarket.

By contrast, greater access to fast-food restaurants, convenience stores, and small grocery stores is associated with decreased consumption of fruits & vegetables and increased intake of energy dense foods. French *et al.* (118) found that the frequency of fast-food restaurant use was associated with higher total energy intake, higher fat intake, more frequent consumption of hamburgers, fries and soft drinks, and less frequent consumption of fiber and fruit. Similar results were found by Satia *et al.* (119), with the frequency of eating at fast-food restaurants being positively associated with saturated fat and total fat intake and fat-related dietary behaviours and inversely associated with vegetable intake. Similar association have been found in other studies (115,120–122).

The suggested mechanism through which the food environment influences consumption patterns varies. Glanz *et al*.'s (123) multi-attribute utility theory of food choice outlined five main variables that play the greatest role: taste, cost, convenience, nutrition, and health, each with varying effect at the individual-level. While taste, the biological preference for food items, has the largest impact on food choice and consumption (124), both price, defined as the monetary cost and affordability of food products, and convenience, defined as the saving of time, physical energy and mental effort related to food preparation and consumption, have been found have greater relevance to an individual's interaction with the neighbourhood food environment. These factors are discussed in greater detail in Section 2.6.

2.4.1.2 Dietary Patterns and Chronic Disease

The development of chronic disease is a lifelong multifaceted process. Exposure to multiple risk factors over a long period can result in the increased risk of developing chronic conditions. Diet and food consumption can have a large influence on the incidence of these diseases.

The mechanism by which dietary patterns can increase the risk of chronic disease development is through the nutritional value of the food that is consumed. The food environment, in turn, influences these dietary patterns by altering the consumption patterns of healthy and unhealthy foods. These associations have been seen in many studies, with energy dense and fast-food intake being associated with poorer diet quality and increased rates of obesity (42,125–127), while diets rich in low energy, nutrient-rich foods, such as fruits, vegetables, and lean meats, have been associated with lower BMI and obesity risk (21,32,44,128,129).

Foods that are classified as healthy, such as fruits, vegetables, lean meats, reduced fat and whole grain products, contain large amounts of nutrients and macromolecules vital for the maintenance of the human body. Two critical appraisals, conducted by Horn *et al.* and Ros *et al.* (21,130), reviewed over 200 papers and found many beneficial properties and effects of these nutrients on health and diet related outcomes. Increased consumption of fruits and vegetables were associated with an increase in healthy dietary fats, such as omega 3 fatty acids, eicosapentaenoic acid (EPA) & docosahexaenoic acid (DHA). An increase in these dietary fats promote reduction in low density lipoprotein levels (LDL) and very low density lipoproteins level (VLDL), risk factors in the buildup of cholesterol and cardiovascular outcomes (21,130). Nutrients and macromolecules, such as dietary fiber, vitamins, minerals, phytochemicals, and antioxidants, were also associated with reduction in antioxidant stress, insulin sensitivity, improved cholesterol profile, lower blood pressure and better cardiovascular outcomes (21,130). Healthy diets, high in fruits, vegetables, and lean meats, have been negatively associated with incidence of chronic diseases such as diabetes (21,128,130–132), hypertension (21,128,130,133), high cholesterol (21,130,134) and cardiovascular disease (21,130–132,134).

In contrast, foods that are classified as unhealthy, such as fast-food and processed food, are rich in saturated and trans-fats, salts, sugars, and energy, macromolecules that are low in nutritious content. While these nutrients are needed in order for human survival, excessive intake of these macromolecules has been associated with the increased incidence and prevalence of many chronic diseases. Excessive sugar intake can cause elevated BMI and insulin resistance, excessive salt consumption has been linked to elevated rates of hypertension, and excessive fat and energy consumption have been found to be significant predictors for most chronic conditions and obesity (21,130). Fast-food consumption in particular is associated with an increased risk of high cholesterol (20,21,126), diabetes (20,21,135), cardiovascular disease (20,21,135) and hypertension (20,21,133).

2.4.2 Body Mass Index and Obesity

2.4.2.1 Obesity and the Food Environment

The quality of the neighbourhood food environment can have varying effects on BMI. This relationship has been heavily investigated, with two trends being predominately seen within the literature. Firstly, increased access and availability of healthy food stores, such as supermarkets and fruits & vegetables stores, have been associated with lower BMI and obesity risk in many studies (44,55,121,136,137) while reduced access has been associated with higher obesity rates (55,97). Morland *et al.* (44) found that the presence of supermarkets within census tracts resulted in a 17% lower risk of obesity compared to census tracts with an absence of supermarkets. A second, opposite trend is seen with the availability of unhealthy food stores, with convenience stores, smaller grocery stores (44,54,136,137) and fast-food restaurants being associated with elevated BMI and risk of obesity (52,63,99,121,136–140). Block *et al.* (141) found that a per 1 km increase in the distance to the closest fast-food restaurant was associated with a 0.11 kg/m^2 decrease in BMI. Similar results have been found in a Canadian setting by Hollands *et al.* (99): an additional fast-food restaurant per 10,000 people was associated with a 0.022 kg/m^2 increase in BMI.

One of the primary mechanisms of weight gain is dietary patterns. Obesity is a result of excessive caloric and energy intake. When caloric intake exceeds the body's metabolic needs, the surplus energy is stored as adipose tissue throughout the body for later use. Constant accumulation of this adipose tissue through repeated excessive intake can lead the gaining of weight over time, resulting in increased BMI and obesity (138,142). As the food environment influences food consumption and dietary patterns, increased accessibility to unhealthy food sources, such as fast-food stores, can result in the consumption of energy dense foods. On the other hand, healthy foods, such as fruits and vegetables, tend to have lower caloric content. As a result, a large number of these foods are associated with reduced risk of obesity (128).

2.4.2.2 Obesity and Chronic disease

Many studies have found associations suggesting an increased risk of chronic disease development due to obesity. Overweight and obese individuals are often reported as having increased rates of high cholesterol, hypertension (143,144), type 2 diabetes (143,145), and cardiovascular disease (21,145,146). Two studies by Sturm (147,148) found that obese individuals report chronic conditions, such as diabetes, hypertension, and cardiovascular disease, 67% more often when compared to normal weight individuals. Similar findings were seen by Costa-Font & Gil (149), who found that obesity increased the probability of diabetes by 43%, the probability of hypertension by 47%, the probability of high cholesterol by about 20%, and the probability of heart disease by about 15%.

The mechanism through which obesity increases the risk of chronic disease development is believed to be through increasing levels of free fatty acids (FFA) within the body’s circulatory systems. Obesity, predominately visceral obesity, has been found to increase FFA production and reduce FFA metabolism within the liver and pancreas (150). This influx of FFAs has been associated with various effects on bodily functions. Excessive FFA not only leads to reductions in its own metabolism, but of high density lipoprotein (HDL), a protein responsible for managing FFA and cholesterol levels in the blood stream. This reduction of free HDL and increase in FFA leads larger levels of free floating LDL and VLDL, risk factors for high cholesterol and cardiovascular disease (150,151). FFAs also induce inflammation, due to immune and cytokine responses along the walls of the blood vessels and arteries around the body’s circulation system, resulting in increased risk of hypertension, cholesterol build up, and cardiovascular disease risk (152,153). FFA can also lead to an increase in plasma glucose levels through the prevention of peripheral glucose intake by the body’s organs and muscles. This causes the pancreas to increase its production and secretion of insulin to compensate.

Overproduction and release of insulin leads to reductions in sensitivity of the insulin receptors and impaired insulin production ability, leading to type II diabetes (150,151,154)

2.4.3 Physical Activity

2.4.3.1 Physical Activity and the Food Environment

Neighbourhood land development, land use, and infrastructure offer access to a wide variety of designs, resources, and facilities that can be conducive or detrimental to pursuing a physically active lifestyle. Features of the environment, such as increased access to physical activity facilities, healthy food stores, neighbourhood walkability, and decreased safety concerns have all been associated with greater physical activity (155–159). The importance of these factors can be further explained through residential self-selection. A neighbourhood that is perceived to have greater availability of desirable traits, such as physical activity facilities and healthy eating opportunities, can lower the perceived burden of engaging in healthy habits. Individuals who value these traits would be more able to select these neighbourhoods to move to and live in, increasing or decreasing exposure based on individual level preference (160,161).

In terms of dietary patterns, individuals that are physically active tend to be health-conscious and have a greater tendency to consume healthier diets. For instance, Huffman *et al.* (162) and Charreirre *et al.* (163) found that greater physical activity levels were associated with healthier diets and Jeffery *et al.* (50) found that greater physical activity levels were associated with reduced fast-food consumption. Similarly, sedentary lifestyles, measured through TV viewing, have been associated with poorer diet quality (162). An individual’s physical activity patterns influences the way they interact with the food environment, promoting the use of different types of food stores to maintain their health.

2.4.3.2 Physical activity and Chronic Disease

A physically active lifestyle has also been associated with reduced risk of chronic disease development. A recent systematic review of 44 randomized controlled trials by Katzmarzyk & Lear (164) found that individuals who engaged regularly in moderate to vigorous physical activity had reduced rates of developing common risk factors associated with chronic disease, such as elevated blood pressure, insulin resistance, blood lipids and cardiovascular inflammation (17,165–168). A prospective longitudinal study conducted by Helmrich *et al.* (169) found that an increase of 500 kcal in energy expenditure per week was associated with a decrease of 6% in the incidence of type 2 diabetes, while Myers *et al.* (170) found that being fit and active was associated with a greater than 50% reduction in risk of cardiovascular related mortality. On the other hand, sedentary lifestyles, such as TV viewing, have been generally associated with greater rates of diabetes and hypertension (168,171,172).

The protective effect seen between physical activity and chronic disease can be explained through two mechanisms. First, from a metabolic standpoint, physical activity results in increased energy expenditure and reduced energy storage as fat compared to less physically active individuals, reducing the risk of obesity and the incidence of chronic disease. Second, regular exercise is also an indicative of greater health consciousness, which can be predictive of other health behaviours that reduce the risk of obesity and chronic diseases. As a result, physical activity has been associated with changes to biological mechanisms similar to obesity and healthy eating. Engaging in physical activity improves lipid lipoprotein profiles (18,173), glucose homeostasis and insulin sensitivity, reduces blood pressure (19,174), and improves cardiovascular function (175), reducing the risk of chronic disease development. Sedentary lifestyles and TV watching have also been associated with greater obesity rates (176), however this association is seen more frequently in children than adults (177).

2.5 Gaps in the Literature

First, while the literature on the relationship between the neighbourhood food environment and chronic disease is limited, there exists a great deal of variability in the methodology used to classify the food environment, define the number and type of exposure measures used in the analysis, the scale at which neighbourhoods are defined, and statistical methods used across various studies. Of the 15 studies that used objective measures of food store availability, 10 used a combination of classifications codes and secondary databases to categorize food stores (44,60–64,66,68,71,72). However, secondary databases are prone to differential misclassification errors (93–95). In order to limit the effects of the misclassification bias, 7 of these studies (62–64,66,68,71,72) used a combination of 2 additional classification methods, retail chain directories and store property characteristic, in order to increase the accuracy of their measures. However, when using directories to identify retail chains locations, 5 of these studies (63,64,66,68,71) limited their categorization to major chains only. Furthermore, the majority of studies used a limited number of food store measures in their analysis. As the food environment is a combination of different types of food stores influencing and directing food choice, limiting the food environment to only a few types fails to capture the range of healthy and unhealthy food stores in the surrounding environment. Only 6 studies (44,53,56,59,61,67) used more than 2 measures of food outlets in their analysis.

Secondly, the types of measures used in order to quantify the food environment are also limited. The majority of studies quantified the food environment through a measure of density, with density being calculated using population (53,56,59,64,67,68) or area and geographic (61,63,66) based data. While a great deal of inconsistency exists when quantifying and classifying the local food environment, the majority of studies found significant associations between the neighbourhood food environment and chronic disease. Of the studies that did not find significant associations, most authors argued weaknesses in the study design rather than the absence of an effect.

Thirdly, another limitation is the lack of Canadian studies investigating the effects of the neighbourhood food environment on chronic disease. The vast majority of studies were from the US, the results of which may not be entirely applicable to Canadian population due to differences in demographic, geographic, and healthcare and social policies. Only two papers were conducted in Canada, Alter & Eny (68) and Daniel *et al.* (66). Although having similar findings between both studies and being comparable to the

US studies, both Alter & Eny (68) and Daniel *et al.* (66) used a limited number of food stores to define their food environment measures.

A fourth gap was the exclusion of possible intermediate variables, such as obesity, physical activity, and dietary patterns, from the analysis. Although all three of these variables have been found to be strongly associated with both chronic disease and the food environment, not all studies adjusted their analyses for these variables. Only 7 adjusting for obesity (56,63,70,72–75), while 8 controlled for physical activity (44,53,56,59,63,69,70,72) and 4 controlled for dietary patterns (63,69,70,72). Furthermore, only two studies, Auchnicloss *et al.* (69) and Dubowitz *et al.*(64), examined the role of BMI, physical activity, and diet as possible mediators in the causal pathway. While Auchincloss *et al.* (69) did find evidence of possible mediation, suggesting that BMI, physical activity, and dietary patterns were partial mediators, there was a lack of formal mediation analysis. Dubowitz *et al.* (64) found limited evidence of physical activity partially mediating the association between hypertension and the availability of fast-food restaurants. However, similar to Auchincloss *et al.* (69), no formal mediation analysis was undertaken. While associated with both the chronic disease and the food environment, there is the lack of clarity in the literature on whether these lifestyle variables should be considered as confounders or mediators in the causal pathway. In the case of confounders, it would be more appropriate to include the said variables in the model while if considered as mediators it would be more appropriate to exclude them.

Chapter 3

3 Conceptual Framework

In this chapter, a conceptual framework driving the relationship between the neighbourhood food environment as a risk factor for chronic disease development is discussed. The neighbourhood food environment as such is unable to directly influence individual level chronic disease risk, instead working through a pathway of intermediary variables. As depicted in Figure 2.1, the food environment influences individual level dietary patterns, leading to the development of chronic conditions. The mechanisms governing the associations between the food environment and food consumption, food consumption and obesity, and obesity and chronic disease were discussed in Section 2.4.

The proximity and availability of food stores have been cited as the most likely reason linking the neighbourhood food environment and food consumption in the literature (178).The increased availability of healthy food stores has been associated with healthier dietary patterns. Supermarkets, which provide a large variety of fruits, vegetables, and healthy food products at lowered costs (111–113,179,180), have been associated with healthier diets and food intake within its surrounding residents (32,37,115,181), while the lack of supermarket availability and other healthy food stores is associated with reduced access to and consumption of fruits & vegetables (97,116,117,182). Similarly, access to and availability of unhealthy food sources, such as fast-food restaurants, convenience stores and small grocery stores, are associated with decreased fruits & vegetables consumption and increased energy dense and fast-food intake (115,120–122,183).

The purported mechanism through which the food environment affects food choice, however, differs across studies. While the food environment can provide access and availability of different types of food outlets, the use and access to these locations is determined at the individual level. Individual level food choice can be driven by many factors, including the preference of the individual. What values and traits an individual takes into account during his/her decision making process can vary based on preference, behaviour, and other factors. Many approaches have been proposed to explain this heterogeneous preference, however, limited consensus exists in the literature. One of the widely used theories is a food choice model proposed by Glanz *et al.* (123) based on a multi-attribute utility theory (MAU) of food choice. This theory is grounded in value expectancy theory, which, in the case of food choice, allows for the evaluation of a food choice preference based on how an individual values, or the importance of, this preference and the expectancy, or the subjective probability, that the food will consumed if this preference is present. For example, if a person believes taste is an important preference when choosing what to eat and he considers a certain type of food to be tasty, he will be more inclined to eat those types of foods and, therefore, access locations that provide it. MAU expands upon this, applying the value attribute theory to multiple influences and preference that can alter food choice at once, with an individual weighing of each preference against each other before making a decision. Glanz *et al.* (123), using the MAU theory, identified 4 main factors that had the greatest impact on food choice: taste, nutrition and health, cost, convenience.

3.1.1 Taste

Taste is the most prominent driver behind food choice and consumption, with individuals ranking taste preferences as having the largest influence on their food choices (124). Taste, or palatability, is defined as the neurological preference to food items due to aroma, texture, and flavour. Biologically, humanity has an increased affinity for unhealthy food products. The consumption of sugars, fats, and energy dense foods has been linked to a neurological dopamine release reward response, creating a natural predisposition for the consumption of these food products. Unhealthy and fast-food items are largely comprised of these ingredients, creating a natural affinity for these items over fruits, vegetables and healthier options. Overstimulation of this pathway through over eating may also result in elevated obesity and chronic disease risk (184–186). Many studies have similarly associated taste as the primary driver behind fast-food consumption (187–189) and reduced intake of fruits and vegetables due to poor taste (190).

3.1.2 Nutrition and Health

The influence of nutritional and health concerns on food choice is growing. While ranked as the least important preference of choices in Glanz *et al.* (123), recent research have found that nutrition and health concerns have begun to exert a much greater influence on food choices (124,187,191). This may be due to an increase of health and diet awareness within the population. With rising rates of obesity and chronic disease, consumers are more conscious about their nutritional needs and health, affecting their food choices and consumption patterns. Individuals that are more health conscious and are more likely to consume fruits & vegetables and pursue healthy dietary patterns (192,193). Alterations in diet and food choice have also been used in order to treat chronic disease (21,194,195). The increase in availability of nutritional knowledge through menu and food labeling may also play a role. The increased presence of nutritional labeling can promote healthier food choices. Nutritional labeling in fast-food and full-service restaurants have been associated with lower caloric intake (196,197) and greater fruits & vegetables intake (198,199).

3.1.3 Price

Price, defined as the monetary cost and affordability of food products, plays a key role in food choices. Studies have consistently found that price is one on the leading factors on food purchase decisions and consumption, with lower cost being associated with greater likelihood of purchasing (200).

Affordability of food has been shown to greatly affect consumption patterns. Unhealthy, energy rich, low nutrients foods are often cheaper than healthy, low energy, nutrient dense foods (201,202). The relatively higher cost of healthy foods may deter healthy food purchasing, resulting in increased reliance and consumption of cheaper, unhealthy alternatives, such as fast-food. Affordability has been cited as a barrier to healthy foods (109,203). Furthermore, the consumption of fast-food and convenience items has been associated with lower costs (187,189), while reduced fruits & vegetables intake has been associated with higher cost (204). The lower cost of unhealthy foods can result in increased consumption, leading to an increased risk of obesity and chronic disease (201,205). The importance of cost in food choice is also seen in deprived neighbourhoods, with low income areas having a reduced ability to afford healthy food products, increasing their risk of obesity and chronic disease (200,202,206,207).

The influence of cost in food choice can also be altered by taxation policy and the design of the surrounding food environment. Supermarkets are able to offer a larger variety of healthy foods at a reduced cost compared to grocery stores and convenience stores (113,179,180). Supermarkets are not equally distributed throughout the population, with deprived areas having limited access to healthy food outlets. The additional cost of transportation and the resources needed to travel to supermarkets can also reduce access and increase overall cost (139,208). These limitations in access creates a reliance on smaller and local food venues, such as small grocery and convenience stores, which carry less healthy food options at higher prices, deterring the purchasing of healthy, low energy, nutrient rich foods (113,179,209,210).

3.1.4 Convenience

Convenience, defined as the saving of time, physical energy and mental effort related to food preparation and consumption, plays a large role in the food choice process (124,187,211,212). The concept of convenience can be explained through time costs and its increasing role in society (211). Time scarcity, due to growing work demands and greater female labour force participation, has resulted in decreased meal preparation at home over the last three decades (211,213,214). Consequently, the proportionate importance attached to the time and energy used in acquiring, consuming, and disposing of food has increased as well. These changes have sparked alterations in food consumption patterns, such as a decrease in food preparation at home, an increase in the consumption of fast foods, a decrease in family meals, and an increase in the consumption of convenience or ready-prepared foods (213–215). These food choices and consumption patterns have been associated with unhealthy diets and an elevated risk of obesity and chronic disease (216,217).

The availability of food outlets within the surrounding environment can affect convenience as well. Relative ease of access and time of transportation to food outlets alter perceptions of convenience, with closer and more abundant food sources being more likely to be utilized. Many studies have found that increased accessibility has been associated with the consumption of fast-food due to convenience (124,125,187,189,215). Transportation and time have been similarly associated with reduced access to supermarkets and fruits & vegetables intake, with objective and perceived measures of availability, distance, and the modes of transportation being associated as barriers to reduced supermarket access (109,117,204,208,215,218).

While each of these factors, taste, nutrition and health, cost, convenience, plays a role in food choice and the relationship between the food environment and consumption, limitations in data availability and the feasibility of measuring affordability, taste, and nutrition and health reduces the ability accurately quantify these variables. Convenience, however, can be empirically estimated through the availability of food sources, with greater exposure and access to food outlets increasing their convenience and use. Furthermore, measures of availability have been widely used as accurate measures for assessing the neighbourhood food environment and convenience (27). In this study, the main mechanism through which food choice affects consumption and the food environment is assumed to be through convenience.

3.2 Confounders

Confounding is a potential source of error that can attenuate and alter the association between an exposure and an outcome. Confounding occurs when a third variable, known as a confounder, experiences an inherent difference in risk between exposed and unexposed individuals (219). Adjusting for potential confounders would provide an accurate estimate of the association between the exposure and outcome variables of interest. In this thesis, the classical criterion of a confounder was used: a variable is defined as a confounder if it was associated (causally or non-causally) with the exposure, causally associated with the outcome, and it is not an intermediary variable in the causal pathway (220).

In order to create a framework driven by theory rather than the data, the inclusion of potential confounders into conceptual framework was performed *a-priori* and incorporated through a comprehensive review of the literature.

Although many studies have found associations between neighbourhood food environment and diet, obesity risk and chronic disease development, it is conceivable that several other neighbourhood level characteristics may explain this association. For instance, certain affluent neighbourhoods are more likely to have a greater availability of resources that are conducive of healthy behaviours such as easy access to parks and recreation centres, better infrastructure, lower crime rates, education facilities, and better access to healthy foods (70). Consequently, these neighbourhoods are able to attract economically well-off individuals with healthier lifestyles. These pathways are outlined in Figure 2.1, with convenience driving the interaction between the food environment and individual dietary patterns, influencing the risks of obesity and chronic disease.

3.2.1 Demographic Confounders

3.2.1.1 Age

Age can be considered a potential confounder due to associations shared with both dietary patterns and chronic disease development. Age has generally been associated with a shift in dietary patterns, with advancing age resulting in reduced consumption of fast-food (125,137), increased consumption in fruits & vegetables (221,222), and generally healthier diets (137,202,223). These changes in dietary patterns may be a result of changing lifestyle patterns associated with aging. Older adults have a greater awareness about their own physical health and the dietary guidelines needed in order to maintain health, pursuing healthier lifestyles and dietary patterns. Middle aged and older adults also have higher incomes, increasing their ability to access and purchase healthier foods. Another possible mechanism is the use of altered dietary patterns in order to manage morbidities for older adults who may have already developed or are at risk of developing a chronic disease.

Increasing age has also been associated with the elevated prevalence of chronic diseases (8,9,224–227) as well as multiple morbidities (228,229). Although prevalence of chronic diseases increases with age, the incidence of chronic disease generally follows a quadratic trend, with a reduction in the incidence of chronic conditions being observed in individuals older than 65 (10,62,226). This reduction in the incidence of chronic disease in older adults may be the result of a survivor's effect, with individuals at a high risk of developing chronic conditions doing so at an earlier age, leaving only adults with a lower risk for developing chronic conditions left in the older age groups.

Similar to chronic disease, age was a significant predictor of elevated BMI and obesity (230,231), and follows a quadratic trend (232,233), with rates of obesity tapering off past the age of 65 (234,235). Increasing obesity rates with age is likely due to physiological changes in body function; with older individuals having elevated rates of visceral fat build up due to decreasing metabolism and the loss of muscle (236), resulting in an elevated risk for chronic disease.

3.2.1.2 Gender

Gender can be a confounder for both food consumption and chronic disease risk. Women have been found to typically consume healthier diets than men. Studies have found that women consume less fast-food (125,216,237), have healthier diets (216,238), and on average consume more daily servings of fruits & vegetables compared to men (115,221,239). These differences in consumption may be due to dissimilarities in societal pressures faced between men and women with respect to body weight and health conscious behaviours. Being overweight and obesity is considered a less desirable trait for women socially, with obese women seeing reductions in marital, educational, and employment outcomes (240).

Although men have a higher reported risk of developing chronic conditions, particularly diabetes (10,11), hypertension, and cardiovascular disease (12,66,241–243), women are often found to have a higher prevalence of these disease (224,242,244). These higher prevalence rates can be explained due to difference in the life expectancy between genders, with women constituting a larger proportion of the elderly population (242). Women past the age of 50 also experience a large increase in chronic disease prevalence and incidence compared to men, particularly of type II diabetes (8,245) and hypertension (242,246). Reductions in estrogen levels due to menopause may be the cause of this, with estrogen being associated with a protective effect against chronic disease development (247,248). The interaction between age and gender was found in one study (249), but not in other studies (250,251). A similar age–gender interaction was found in blood pressure levels (252)..

3.2.1.3 Ethnicity

Individual ethnicity is a potential confounder as it can affect one's dietary patterns and chronic disease risk. Food consumption can be influenced by a person's ethnicity, with cultural dietary patterns and preferences toward certain types of food directing overall diet quality and intake. Evidence of differences between ethnicity and diet quality is well documented within the literature. Caucasians are associated with having generally higher quality diets, greater fruits & vegetables intake, and reduced fast-food intake compared to most visible minorities, particularly African Americans and Hispanics (137,253–255). Similarly, Chinese-Asian individuals tend to have both healthier diets and reduced fast-food intake compared to other races (137). Access to food stores differ by race as well, with racial minorities, predominantly Hispanics and African Americans, being found to have greater access to unhealthy food outlets (137) and reduced access to healthy food locations (116,256) in their surrounding neighbourhoods.

A great deal of variation exists between race and chronic disease prevalence. Caucasians generally report lower chronic disease incidence compared to visible minorities, with African Americans, Hispanics, Filipinos, and South East Asians report higher rates of diabetes, hypertension and cardiovascular disease (10,12,13,62,243,257–259). Furthermore, South Asians and American Indians are associated with a higher risk of diabetes (12,13,257,258), hypertension (12,227,259,260) and high cholesterol (12) compared to other racial groups. Studies have also found a positive association with cardiovascular risk among individuals of Caucasian decent (12), whereas others have found an elevated prevalence of cardiovascular disease in African Americans (261,262), American Indian (227,258,263) and South Asian ethnicities (227,258) when compared to other races. Being of East Asian decent was also associated with a reduced risk of chronic disease prevalence compared to other ethnicities (12,227,258). These findings in the literature could be the result of a thrifty gene effect, with metabolically unfavourable genes among certain ethnic group leading to increased fat storage, BMI levels, and an increased risk of chronic disease development. For example, South Asian descent has been associated with a genetic predisposition for the accumulation of visceral fat, a well-known risk factor for chronic disease development (12,264,265).

Similar to chronic disease, some minority groups experience an increased risk of elevated body weight and rates of obesity, particularly among African American (266,267), Hispanic (266), Aboriginal (243,268) and South Asian (264) communities, while East Asian decent has been associated with lower BMI and obesity (257,266,268). Based on ancestral patterns of human evolution, certain ethnicities may be genetically programmed to have specific metabolism traits linked to survival. These "thrifty genes", while metabolically beneficial in the past, may result in greater risk of chronic disease and obesity when interacting with the unhealthy food environment (269).

3.2.1.4 Immigration status

Immigration and duration of residency have been associated with food consumption patterns, chronic disease, and BMI through an acculturation effect. Immigration laws tend to prioritize young, educated individuals as ideal candidates for residency over unhealthy, older individuals. In addition, some recent immigrants tend to have healthier diets, are at a reduced risk for the development of obesity and chronic diseases (270) and are more likely to consume ethnic foods (271,272). This is due to recent immigrants' desire to maintain their home country's dietary habits and lifestyles rather than acclimatizing to those of their adopted country (273). Over time, however, this protective effect tends to fade, with migrants slowly adapting more sedentary lifestyles, consuming more unhealthy foods (270,274,275), and increasing their use of unhealthy food outlets, such as convenience stores and fast-food restaurants (258,270,275,276). This process is referred to as "dietary acculturation" (270), with the initial protective effect decreasing as years of residency increased. Acculturation, proxied through the duration of residency, is associated with increased prevalence of high cholesterol (277), diabetes (278–281), hypertension (278,282), cardiovascular disease (283), and increased BMI and elevated risk of obesity (268,277,284,285) when comparing recent and long term immigrants.

3.2.2 Socioeconomic Confounders

3.2.2.1 Individual Income

Individual income as a potential confounder is well known in the literature. Individuals with higher income tend to consume healthier diets. This association is most likely seen due to high income individuals having larger disposable incomes, enabling them to afford high quality and expensive foods. Healthy diets, containing nutrient dense, low energy foods, tend to be more expensive (286), resulting in lower income individuals relying on cheaper, unhealthier diets, consisting of prepackage, energy dense, and fast-food alternatives (287). In the literature, high income, measured either at the individual or household level, is associated with greater fruits & vegetables intake (159,216,253,288,289) and greater access to healthy food stores (37,71,255). In contrast, low income has been associated with greater fast-food consumption and fat intake (122,216,290).

Chronic disease risk exhibits an inverse association with income, with rates of diabetes (10,16,279), hypertension (225,291) and cardiovascular disease (292) increasing as individual income decreases. Higher income allows individuals to afford healthier resources, diets, and lifestyles, resulting in a lower risk for chronic disease development. These effects are seen more consistently and strongly in women than in men, particularly with diabetes (15,293) and cardiovascular disease (293–295). Differences between the genders could be due to societal expectation between genders. Women face a social stigma to not be overweight, as heavier women having reduced employment opportunities or high-paid jobs, if employed (296). As a result, women invest their wages differently than men, engaging in healthier behaviours and eating habits in order to maintain better health (297), factors that are attributed to lower chronic disease risk. This social gradient does not seem to affect men; in fact, it goes in the opposite direction for men in higher management and supervisory positions (298).

Women have consistently been found to have an inverse association between income and overweight/obesity risk, whereas men have a positive association, with the risk of obesity increases as income increases (230,231,234,268,298,299). The association with men is also seen (300), but stronger in the highest income group (299,301). These differences can again be attributed to differences in societal expectation between genders, with women investing their income and time differently because of a greater value of health and to prevent weight gain (297).

3.2.2.2 Education

The role of education as a potential confounder is similar to individual level income. Higher education has been associated with healthier diets (289,302) and greater fruits & vegetables consumption (288,303), while lower education is associated with poorer diet quality (304) and increased fast-food consumption (290,304). Individuals with higher academic achievement are able to seek employment opportunities that offer higher wages, allowing them to have more disposable income to purchase quality foods and pursue healthier behaviours. Having a higher education may further encourage a healthier lifestyle through a greater knowledge and understanding of the importance of nutrition and physical activity in health maintenance, resulting in a healthy lifestyle and lowered chronic disease and obesity risk.

Studies have also reported a positive association between education and fast-food consumption (237,305,306). This could be due to highly educated individuals being able to afford to eat out more often compared their lower educated counterparts. Individuals with higher academic achievement were also more likely to eat healthier foods when using fast-food outlets (304,305), and eat at full-service restaurants, which offer a larger variety of healthy choices compared to fast-food and takeout outlets (307,308).

Similar to individual level income, the risk of obesity and elevated BMI was negatively associated with education (298,300,309,310), with this relationship being seen more strongly in women compared to men (300,311–313). Specifically, higher academic achievement was associated with reduced hypertension (14,293,311), high cholesterol (293,311), diabetes (15,16,293,313) and cardiovascular risk (294,313). Again these effects were more prominent in women than in men (15,294,295,313). These differences between the genders are similar to income, with more educated women feeling greater societal pressure and stress not to be overweight as discussed earlier.

3.2.2.3 Marital Status

Marital status is another socioeconomic variable that can be considered as a potential confounder. Compared to divorced, widowed, and single individuals, married individuals are more likely to have healthier diets (202), containing more fruits & vegetables (314–316). Furthermore, being unmarried was associated with poorer overall diet and increased fast-food consumption (317,318). The change in diet after marriage can be attributed to increased opportunities and obligations for food consumption through larger portion sizes and shared meals with their respective families, referred to as the social obligation hypothesis (319–321). Married individuals also have higher overall household incomes, allowing them to purchase higher quality food, such as fruits and vegetables.

Studies have reported that marital status has a protective effect against the development of chronic disease, with a reduced risk of cardiovascular disease (322,323), diabetes (324,325), and hypertension (326,327) being seen in married individuals compared to never married, divorced, and single persons. However, recent studies have found no significant association between marital status and chronic disease as well (246). This protective effect may be a result of spousal care and greater life satisfaction, with a spouse providing additional care and preventing the development of chronic disease. Unhappily married individuals also reported poorer health outcomes, greater amounts of stress, depression, and poor lifestyle choices, risk factors for chronic disease (319,322,325). Furthermore, widowed individuals also seem to have an increased risk of cardiovascular disease compared to other marital groups; however this association is predominately seen within older individuals (328).

Marriage, both first marriage and remarriage, have been associated with weight gain and elevated risk of obesity (231,320,329), while transitioning out of marriage, either through divorce, widowing, or separation, has been associated with reduced BMI and weight loss (316,320,329,330). This gain in weight after marriage has been hypothesized to be a result of married individuals being less likely to engage in physical activity and reduced weight maintenance as they no longer need to attract a spouse, referred to the marriage market theory. Furthermore, increased food intake through the social obligation theory can increase caloric intake, leading to elevated body weight. Obesity also has a bidirectional effect on women and marriage, as obese women are less likely to enter into a marriage (331) and never married women are more likely to have elevated risk of BMI compared to divorced, separated, and widowed women (330). This may be a result of obesity being seen as an undesired trait in spouses, resulting in decreased odds of obese women entering into a relationship (320,332). A similar mechanism results in weight loss seen after the loss of a spouse, with both men and women losing weight in order to be more desirable and attract members of the opposite sex (319–321,332).

3.2.3 Lifestyle Confounders

3.2.3.1 Smoking Status

Both smoking and drinking can be considered as potentially confounding lifestyle variables. Smoking has been associated with unhealthy food consumption patterns, with smokers generally have lower fruits & vegetables intake (333), greater fat intake (334) and lower quality diets (335–337). This can be explained due to differences in lifestyles between smokers and non-smokers. Smokers are generally less health-conscious compared to non-smokers and have been found to be less likely to engage in healthy diet patterns (338).

While smokers are likely to engage in unhealthy dietary patterns, an opposite trend was seen with BMI and obesity risk, with smokers reporting lower BMI levels compared to non-smokers (231,299,339). This difference in BMI can be attributed to the physiologically effects associated with nicotine intake, a key ingredient in cigarettes. Nicotine has been found to result in reductions in appetite and increased expenditure of total energy, resulting in reduced fat storage and weight loss (338). However, as smokers are less health-conscious, they tend to have poorer dietary habits that are conducive of obesity and other unhealthy behaviours, such as reduced physical activity. As a result, the cessation of smoking has been found to cause an increase in BMI in former smokers (33,339). Gender disparities have been found in smoking status as well, with women using smoking as an alternative method of weight control (33,336).

Smoking status has been associated with an increased risk of developing several types of cancers and chronic diseases, particularly of the cardiovascular and respiratory systems (340,341). This is most likely a result of cigarette smoke inhalation resulting in increased levels of total cholesterol, triglyceride, and LDL while reducing HDL levels due to altered functionality in lipoprotein lipase (342). Similar findings have been found with diabetes, with a meta-analysis of 25 papers assessing smoking status and diabetes risk finding that 24 reported a relative risk of diabetes as greater than 1 (343). Other studies have found that smoking status has been positively associated with elevated blood pressure and hypertension (344,345). This may be due to nicotine causing an increase in insulin production due to over stimulation of the sympathetic nervous system, resulting in insulin resistance over time (342).

3.2.3.2 Drinking Status

Similar to smokers, greater frequency of alcohol consumption has been associated with low quality dietary patterns (337,346), with these individuals being more likely to consume non-nutritional foods (347). However, compared to smoking, alcohol consumption has been found to have an opposite effect with BMI, with studies finding an association between elevated BMI and moderate to heavy alcohol consumption (33,348). The association between alcohol and chronic disease is slightly more complex. Habitual and moderated consumption of alcohol has been found to be associated with a lower incidence of cardiovascular disease in a systematic review conducted by Rimm *et al.* (349), while a review conducted by Koppes *et al.* (350) found a similar association with type 2 diabetes incidence. A study by Mukamal *et al.* (351), however, found that these protective effects are predominately seen in individuals who engage in healthier lifestyle patterns, such as physical activity and healthier diets. Heavy consumption of alcohol, however, was associated with increased prevalence of chronic conditions, including hypertension (352,353), cardiovascular disease (353,354), diabetes (354), and an increased risk of developing multiple digestive system related cancers (353,354)

The mechanism through which alcohol may result in alterations of diet, obesity, and chronic disease risk can be explained through 3 pathways. Alcohol is very high in caloric content. As a result, heavy consumption can lead to the creation of an energy surplus within the body's metabolic pathway, resulting in increased fat storage and weight gain (355). Furthermore, alcohol consumption has also been associated with an appetite-enhancing effect, resulting in increased of food consumption when intoxicated. Individuals who heavily consume alcohol tend to live poorer lifestyles, consume lower quality diets and engage in limited physical activity (356), resulting in an even greater energy surplus and increasing BMI and the risk of obesity (355). Excessive alcohol consumption over time also reduces the functionality of the liver, resulting in impaired metabolism and storage of macromolecules within the body. This can lead to increased LDL and cholesterol levels and impaired glucose metabolism, increasing the risk of developing chronic disease (357,358).

3.2.4 Neighbourhood Level Covariates

Neighbourhood level variables may influence the availability of and access to different resources in the surrounding environment. The features and qualities of the surrounding environment are represented as covariates in this thesis. For this study, five major neighbourhood covariates were used.

3.2.4.1 Neighbourhood Income

One of the characteristics that can shape the surrounding neighbourhood environment is neighbourhood-level income. Neighbourhoods designed to attract high socioeconomic status individuals are built to have resources that are appealing to potential buyers. Furthermore, resources that promote healthier lifestyles increase property value and living costs, limiting the ability of low income individuals to afford living in these areas. As a result, high income individual seek out and are able to afford neighbourhoods that promote healthier lifestyles, such as parks and recreation centres, better infrastructure, lower crime rates, better schools, and better access to healthy foods (70). In regards to the food environment, high income neighbourhoods have been associated with greater availability of healthy food outlets, such as supermarkets, large grocery stores, and fruits & vegetables stores (44,98,137). Furthermore, low income neighbourhoods were generally found to have unhealthier food environments (71,359), with greater availability of fast-food and full-service restaurants (37,54,360), convenience stores, and small grocery stores (44,98,255,361). Low income neighbourhoods are deprived of healthy food stores as well, with these areas having reduced access to supermarkets and fruits & vegetables outlets (37,98,360,361). The quality of food available also differs between neighbourhood income levels, with food stores within low income neighbourhoods being less likely to stock healthy food items (37,362–364) and carry a greater amount of energy dense foods (37) compared to wealthier neighbourhoods.

These neighbourhood level features, such as increased availability for healthy food options, are conducive of healthier lifestyle choices at the individual level (67,365). Obesity was inversely associated with neighbourhood income (52,366–368), with these association being seen more strongly among women (369). Neighbourhood income was found to have an inverse association with chronic disease risk; higher neighbourhood income was associated with decreased rates of diabetes (53,71,370,371), hypertension (371,372) and cardiovascular disease (291,371). Similarly, neighbourhood deprivation was inversely associated with diabetes rates (16,371,373,374), hypertension rates (371,374,375) and cardiovascular disease risk (371,374). Low socioeconomic status neighbourhoods have higher rates of noise, crime and poverty, which increase the stress on individuals living in these neighbourhoods and increase the risk of chronic disease development (67,376,377).

3.2.4.2 Neighbourhood Education

Neighbourhood education was also associated with obesity and chronic disease risk. The effects of aggregate level education function through a pathway similar to neighbourhood income. Individuals with higher education are able to afford living in neighbourhoods that offer a large variety of resources. Neighbourhoods with higher education having found to have better access to parks and recreation centers, better infrastructure, lower crime, better schools and better access to healthy foods (70). As a result, these areas have been found to be associated with greater concentration of supermarkets and fruits & vegetables stores (66,360), and have greater access to healthy foods (378) relative to low education neighbourhoods. In contrast, neighbourhoods with lower overall education levels have greater access to fast-food restaurants (378) and lower availability of healthy foods (378).

Neighbourhood level education status has also been associated with a reduced risk of chronic disease and obesity. Low educated neighbourhoods are associated with elevated obesity and BMI rates compared to more educated neighbourhoods (52,56,231,366). Similarly, area level education has an inverse association with hypertension (14,379), diabetes (380) and cardiovascular disease risk factors (291). Individuals with a higher education may have a greater awareness and the knowledge needed to use healthy resources in the surrounding area.

3.2.4.3 Neighbourhood Ethnicity

Predominately Caucasian neighborhoods have a greater availability of supermarkets compared to racially mixed areas (98,381,382), while racially mixed neighbourhood have been found to have lower availability of healthy foods (37,362,363,383) and fresh fruits and vegetables (136,204,364,382). Significant differences in healthy food access exist across visible minorities neighbourhoods (384), with African American (136,256,364,382) and Hispanic (98) neighbourhoods have lower access to supermarkets. Minority neighbourhoods also have a greater availability of unhealthy food outlets, such as greater concentration of small grocery stores, convenience stores (37,381,384,385), and fast-food restaurants (37,255,359,386,387). Minority neighbourhoods also have greater access to different ethnic foods and stores (271,272,382,388). Neighborhood ethnicity is related to food environment and chronic disease risk through a similar mechanism as neighbourhood socioeconomic status. Neighbourhoods that are predominately racially mixed or minorities tend to have limited neighbourhood resources (67,365) and are targeted by lower income individuals and immigrants due to their reduced housing costs (389,390). Fast-food and unhealthy food locations also target and advertise in minority and low income neighbourhoods (391). The lack of availability of healthier food stores, exercise facilities and higher quality education facilities can then go on to promote poor lifestyles choices, increasing rates of obesity and chronic disease (67,365,385).

3.2.4.4 Transportation

The mode of transportation is considered to be a potential covariate as it can influence how an individual interacts with the surrounding built environment. Transportation can influence access to different food stores and food choice through affordability and convenience. The cost of transportation and the resources needed to travel to food stores have been associated with reduced access and increase in the cost of food purchasing (120,208), whereas decreased convenience and time have been associated with reduced access to food stores (109,215,392,393). Access to cars and motorized vehicles have been associated with increased mobility, limiting reliance on the immediate food environments (122), while reduced access to motorized vehicles and increased reliance on active transportation has been associated with reduced access, greater cost, and greater distance to food stores (394).

Developed neighbourhoods have greater walkability, safer environments, and greater public transport access, which have been associated with greater amounts of walking, cycling and public transport, conductive of active living (395,396). Deprived individuals also have been associated with reduced access to private means of vehicular transportations and an increased reliance on public transportation due to a limitations in access and affordability of transportation (397,398). As a result, these individuals are more likely to experience the additional barriers of time commitment and cost of transportation when accessing food stores, affecting their food environment and consumption patterns (98,394,399).

Differences in the health status associated with modes of transportation can be explained through physical activity. Modes of transportation that involve greater degrees of physical exertion, such as walking, cycling, and public transportation, are more likely to result in greater physical activity levels. These modes of travel, referred to as active transportation, have been associated with greater levels of physical activity (400) and meeting daily activity requirements (156), while the opposite association has been seen with car travel (401). This increase in physical activity results in a larger energy expenditure, lowering the risk of obesity and chronic disease. Recent systematic reviews have found that the use of active transport was also associated with lower obesity and overweight risk compared to car use (402,403), while other studies have found that increased used of motorized vehicles and cars was associated with increased obesity rates (156,404,405). Active modes of transport have been associated with lowered rates of diabetes (406), hypertension (406) and cardiovascular disease (403,407,408), while greater car use has been associated with an elevated risk of chronic disease (407).

3.2.4.5 Population Density

Population density is an aspect of the built environment that influences the food environment through urbanicity and land mix use. Access to a food outlet tends to generally follow an urbanicity gradient; rural, suburban, and urban areas, commonly classified through increasing population density (64,409,410). Highly urbanized areas tend to have higher population densities and more land zones dedicated to commercial use, leading to an increased likelihood of food stores and restaurants being available in these locations (409). All else equal, a higher population density also leads to increased local demand for food outlets and public transportation. Wilde *et al.* (411) found that neighbourhood blocks with high population densities generally had closer proximity to supermarkets. Similar trends have been seen with other store types, with Rundle *et al.* (412) finding an increase in the availability of retail food outlets with increasing population density and Langellier *et al.* (413) finding an increase in the density of corner stores and fast-food restaurants with increasing population density.

Theoretically, neighborhood-level population density may affect chronic disease and BMI through alterations in land mix use and urbanicity. Population dense areas have greater availability of resources, such as higher walkability, healthy food resources and transportation facilities, leading to healthy behaviours and active transportation (414,415). Lopez (367) saw this empirically, with residential density being found to be inversely associated with obesity in the US, while similar associations have also been suggested in Canada (416,417). However, high population density could lead to pollution and safety concerns. Two studies by Chiax *et al.* (418,419) found that areas with high population density had higher levels of air and noise pollution, and increased consumption of fast-food, tobacco, and alcohol, factors that increase the risk of chronic disease.

3.3 Directed Acyclic Graph

As seen in Figure 2.1 below, the proposed causal pathway is visualized through a Directed Acyclic Graph (DAG). The literature supporting these pathways has been discussed in Section 2.4, Section 3.1 and Section 3.2. As the neighbourhood food environment is a neighbourhood level variable, it is unlikely to have a direct causal effect on chronic disease development. Instead, it must act through individual level variables in order to affect chronic disease development. In this thesis, it is proposed that local food environment, through convenience, is able to influence individual level dietary patterns. Dietary habits in turn directly influence obesity and chronic disease development. The association between neighbourhood level food environment and chronic disease can be confounded by demographic variables (age, gender, race and immigration status), lifestyle variables (smoking, drinking and physical activity levels), and socio-economic variable (income, education and marital status). Other neighbourhood level features, such as neighbourhood level income, education, ethnicity, population density, can alter and shape the surrounding environment, such as the type and number of stores that compose the food environment.

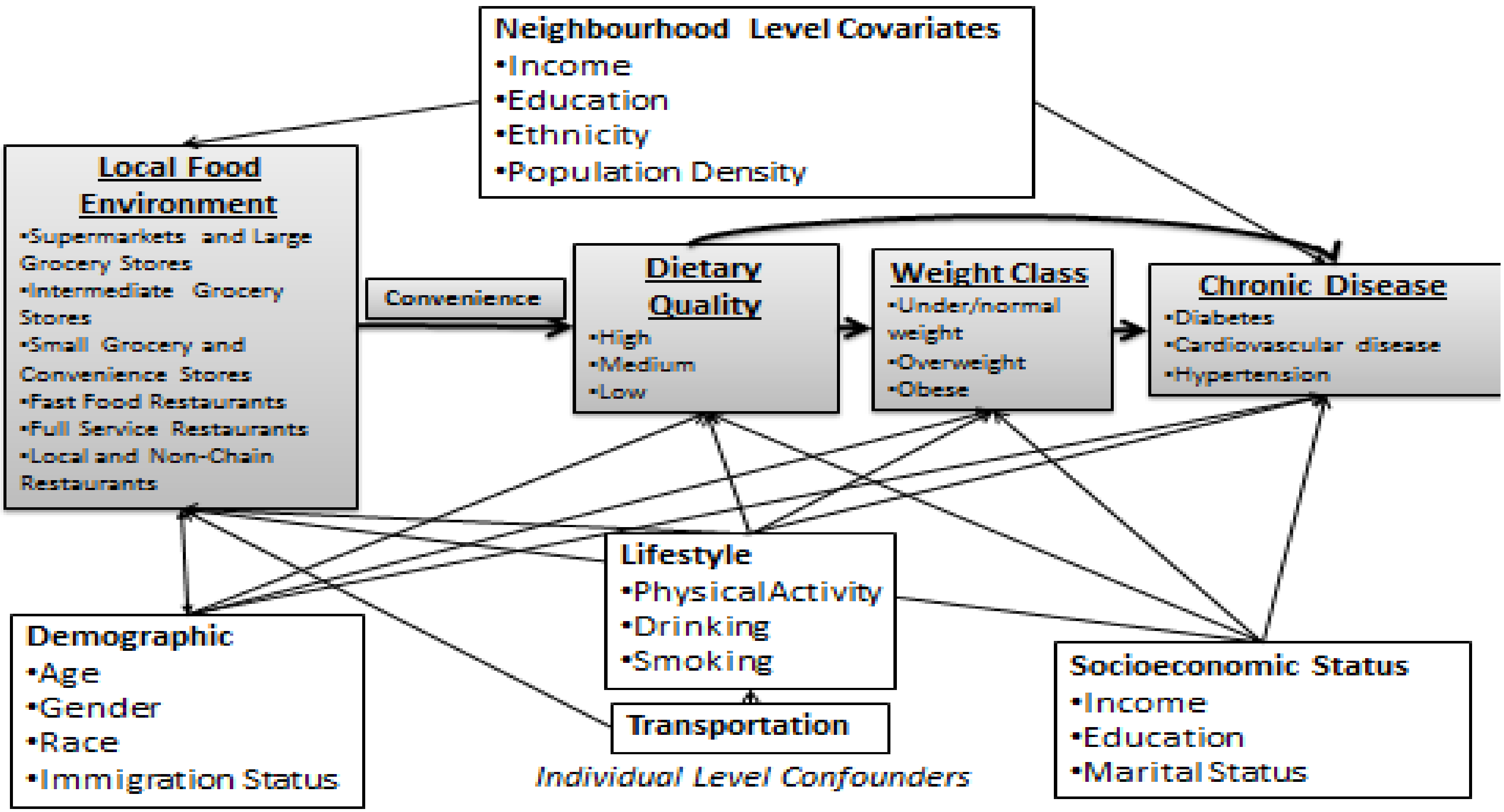

Figure 2.1 DAG Concept

Chapter 4

4 Methods

This chapter will outline the methodology used to conduct the analysis through seven sections. The first section outlines the relevant data sources used for the study. Sections two through five will summarize the construction of the exposure and outcome measures, as well as the mediating and confounding variables that were included in the study. The inclusion of all variables was based on the conceptual framework outlined in the previous chapter. The final two sections will outline the study population and discuss the statistical methods used..

4.1 Data Sources

The data for this thesis came from 3 separate sources:

(1) 2009-2010 Canadian Community Health Survey (CCHS) Master file.
(2) 2011 CFM Leads Business Dataset containing the location of various food outlets across Canada.
(3) 2011 Census and National Household Survey.

4.1.1 2009-2010 Canadian Community Health Survey (CCHS)

Individual level data were taken from the Canadian Community Health Survey (CCHS) conducted by Statistics Canada. The CCHS is a cross-sectional survey, collecting data from the Canadian population with regards to health status, health care utilization, and health determinants. The target population of the survey was individuals over the age of 12 who lived in private dwellings in 117 health regions across the provinces and territories in Canada. Statistics Canada adopted a multi-stage, stratified cluster sampling design. Criteria for exclusion from the survey included those living on Indian Reserves and Crown Lands, residing in an institution, being a full-time member of the Canadian Forces, or residing in certain remote regions in Canada (420).

The CCHS used three sampling techniques to select households: 49% of the sampled households were gathered using a Labour Force Survey (LFS) area fame sampling method, which used a combination of stratified and cluster geographic sampling method. The remaining 50% used a combination of a telephone list frame (49%) and random digit dialing (1%). A total sample of 172,671 was initially selected for this cycle. Out of this total sample, 131,486 individuals responded to the survey, resulting in an overall response rate of 76.1% for the 2009-2010 survey. Greater details describing the methodology used for data collection by Statistics Canada can be found elsewhere (420,421).

The CCHS provided survey sampling weights for use in the data analyses. Weights are assigned values given to each survey participant that denotes the number of individuals in the Canadian population he/she was representative of. In case of the CCHS, these weighted values correspond to the number of persons in the Canadian general population that are represented by the survey respondents. As the CCHS used two overlapping sampling frames with separate sampling techniques, when calculating the weights for the study population, household level weights were calculated independently for the area and telephone sampling frames. These household weights were then combined into a single set of values through an "integration" step, implemented using a dual-frame technique, which was used as the final person-level weight after a few final adjustments by Statistics Canada (421).

For this thesis, the CCHS confidential master file was the primary source of individual-level data. The master file provides un-suppressed and continuous data that were not available in the public use micro data files. Many variables, such as age, BMI, ethnicity and income, were either recategorized into categorical variables or suppressed in the public CCHS files due to small cells to maintain confidentiality of respondents, resulting in the need for the raw data the master file provided. Furthermore, the master file provided 6-digit postal codes for each of the survey respondents, allowing for the creation of the neighbourhood measure used to construct and link to the food environment data. The 2009-2010 CCHS master file was accessed and analyzed in the Statistics Canada's Research Data Centre (RDC) at the University of Western Ontario.

4.1.2 2011 Census and National Household Survey

The 2011 Canadian National Household Survey (similar to Census data collected in previous years but voluntary in nature) was used to compile neighbourhood level variables at the Forward Sortation Area (FSA) level. FSAs are the first 3-digits in the standard 6 digit Canadian postal codes and considered as proxy for neighbourhoods in this thesis. The rationale for this is provided in section 4.2.1.1. A total of 1,621 FSAs were found in Canada's 2011 Census data. Neighbourhood variables at the FSA level were merged to the corresponding FSAs of the respondents in the CCHS 2009-2010 Master file.

Two different types of measures were gathered from the 2011 Canada Census and 2011 NHS. The first was the total area per FSA, measured as km^2, calculated using the 2011 FSA Boundary File available through Statistics Canada website (422). The boundary file was inserted into ArcGIS 10.1, and using a combination of the North American 1983 Corrections and Conditional Release Statistical Statistics Canada projection and the calculate geometry function, individual area counts per FSA were obtained. The second was the 2011 Census population counts per FSA, available through the CHASS Data Centre, which contains a collection of on-line databases and custom built search and retrieval programs that are maintained by Computing in the Humanities and Social Sciences (CHASS) at the University of Toronto (423).

Data with regards to the 2011 Census data on neighbourhood covariates were obtained through the CHASS Data Centre. Previous iterations of the Census collected data on neighbourhood level socioeconomic status, ethnicity, and transportation through the long form census questionnaire, more widely known as Census Form 2B. However, in the 2011 Canada Census, Statistics Canada replaced this long form with the National Household Survey (NHS), a new voluntary, self-administered survey designed to collect social and economic data about the Canadian population (424). The use of the survey was not without weaknesses. The NHS had significantly higher non-response rates compared to the previous long form census. At the national level, the total NHS Global Non-response Rate was 26.1% compared to 6.5% from the 2006 long form census, resulting in reduced data quality (425). While the response rates for the 2011 NHS may be of lower quality, using a more recent source of data can better represent the socioeconomic status in the population. The final responses are weighted so that the data from the sample more accurately represent the NHS's target population. The weighting process involved calculating initial sampling weights of roughly 3, and then adjusting the weights for the survey's total non-response and calibrating them against census population totals at a geographic level (424).

4.1.3 2011 CFM Leads Business Dataset

Food outlets data in Canada for the year of 2010 was obtained through the CFM Leads Canada 2011 Business Data. CFM Leads is a business data holding company that specializes in compiling lists of business outlets by collecting data from multiple sources, such as public directories like the yellow pages, relevant association directories, and telephone directories. While all food outlet information is not guaranteed to be perfectly accurate, CFM Leads claims that their data lists are up to 85%-95% accurate (426), with all entries being frequently run through the National Change of Address (NCOA) database and cross checked against new movers list. For all intents and purposes within this thesis, the data set is assumed to be sufficiently accurate. This data set contained individual data holdings on the name, address, postal code, Standard Industrial Classification (SIC) name, 4 digit main code, and 2 digit sub codes, as well as categorical measures on employees count and annual sales volume.

The CFM dataset was first entered into the ArcGIS program and joined using their postal codes to the DMTI CANMAP Postal Code and DMTI CANMAP Retired Postal Code layers in order to link to the food outlets to their corresponding longitudinal and latitudinal coordinates. Any remaining observations that were missing postal codes but had available civic addresses were then geocoded in ArcGIS 10.1 using the NA_10 North American Locator. Geocoding is the process of matching raw address data to a digital spatial data set and corresponding information, which provided latitude and longitude coordinates (80). All locations were scored at less than 100% match were then reverse gecoded using the STATA 12, Geocode3 coord function and address function in order to obtain full postal codes. Any remaining locations that were left unmatched after the automation processes were then manual internet searched using Google Maps. From these processes, 136823 food outlets were obtained for subsequent analysis this study.

4.2 Variables

4.2.1 Exposure Measures

Based on information available in the CFM database, 6 distinct types of food outlets were constructed to define the food environment. The exposure measures were calculated as density at the Forward Sortation Area (FSA) level. Two types of density measures were used in order to better capture the local food environment.

Population Density:

The first was as a population density variable. It was calculated by dividing the total number of each food outlets by the total population counts within each FSA based on 2011 Census FSA population counts and 2011 CFM Leads dataset. These measures were defined as the total number of each food outlets per 10,000 individual within each FSA, as listed below:

1) *Fast-food Restaurant Density**:** defined as the number of fast-food chain outlets per 10,000 populations in the respondent's FSA.*

2) *Full-service Restaurant Density: defined as the number of full-service chain outlets per 10,000 populations in the respondent's FSA.*

3) *Local and Non-chain Restaurant Density: defined as the number of non-fast-food or non-full-service outlets per 10,000 populations in the respondent's FSA.*

4) *Supermarket and Large Grocery Store Density**:** defined as the number of supermarket and large grocery store outlets per 10,000 populations in the respondent's FSA.*

5) *Intermediate Grocery Store Density: defined as the number of medium grocery outlets per 10,000 populations in the respondent's FSA.*

6) *Small Grocery Store and Convenience Store Density: defined as the total number of small grocery and convenience store outlets per 10,000 populations in the respondent's FSA.*

Total Area Density:

The second variable was based on an area density measure, calculated using the 2011 Census total FSA Area (km^2). These measures were defined as the total number of each food outlets per km^2 within each FSA, as listed below:

1) *Fast-food Restaurant Density**:** defined as the number of fast-food chain outlets per km^2 in the respondent's FSA.*

2) *Full-service Restaurant Density: defined as the number of full-service chain outlets per km^2 in the respondent's FSA.*

3) *Local and Non-chain Restaurant Density: defined as the number of non-fast-food or non-full-service outlets per km^2 in the respondent's FSA.*

4) *Supermarket and Large Grocery Store Density**:** defined as the number of supermarket and large grocery outlets per km^2 in the respondent's FSA.*

5) *Intermediate Grocery Store Density: defined as the number of medium grocery outlets per km^2 in the respondent's FSA.*

6) *Small Grocery Store and Convenience Store Density: defined as the total number of small grocery and convenience store outlets per km^2 in the respondent's FSA.*

In order to reduce the influence of rural FSAs and FSAs with small population counts, a cutoff of at least 1000 individuals at the FSA was used when generating the population and area density measures. Similar methodologies and population size cutoffs were used in the study by Alter and Eny (68) while assessing the association between the food environment and chronic disease using FSA level measures in Ontario. Furthermore, areas with exceptionally large numbers of food outlets, limited population size and limited area size can result in inflated density measures. As a result, the top 1% of FSA density values within each food outlet (n=16) were removed from the study population in order to reduce the influence of extreme outliers in the analysis. All FSAs within Nunavut, Yukon, and Northwest Territories were also removed from the sample (n=9).

4.2.1.1 Geographic Scale

In the current literature there exists a great deal of variation in how neighbourhoods are defined and quantified. As stated in the literature review, the choice of geographic scale used to define neighbourhood varies between studies. This has led to a great deal of debate as to the level of geographic scale used to represent neighbourhoods. Defining the size and magnitude of a neighbourhood can be done through multiple methods, ranging from a historically basis, to residential characteristics, administrative boundaries, and individual perceptions, each dealing with their own unique set of methodological and conceptual issues (57). For example, neighborhoods defined on the basis of people's perceptions can help more accurately identify social interactions and social cohesion, while geographically defined neighborhoods are more relevant when features of the physical environment are considered. For the sake of this thesis, neighbourhoods were defined geographically, as the immediate area in which a person resides (57).

In this thesis, Forward Sortation Areas (FSAs) were chosen over other administrative boundary areas in order to quantify the surrounding neighbourhood and the local food environment. Firstly, due to errors and a lack of information commonly found within secondary databases, complete civic addresses of all food stores were not available for many locations found within the business registration database, making accurately geocoding the records to other administrative area identifiers difficult. These databases did provide postal code for the majority of the records, through which FSAs can easily be identified and derived. FSAs also provide a sufficiently large geographic area to quantify the food environment. Dissemination Areas (DAs) and Enumeration

Areas (EAs) can be too small to capture the food environment within each of the respondent's local food landscapes. Census tracts, due to their larger size, can more accurately measure this activity space. However, due to their larger size, using census tracts may include food locations that may not influence the neighbourhood food environment or fall within the activity space of the study participants, leading to spatial aggregation errors when geocoding observations into large area units (77). Apparicio *et al.* (78) found similar results, recommending the use of smaller spatial units which are contained within census tracts, such as FSAs, as they are able to better capture a more individualized measure of the spatial distribution. FSAs can provide a reasonably large geographical area to capture some measure of the activity space while being small enough to not exceed boundaries of the immediate food environment around a residential address. FSAs were designed for efficient mail delivery, with the size of each FSA varying by urbanicity. As a result, rural FSAs tend to cover large areas while urban cores encompass smaller areas. In this study, rural FSAs are excluded from the analysis.

This use of FSA to quantify neighbourhood when measuring the food environment has been done in several other Canadian studies (68,427–429). Black *et al.* (430), assessed the association between socio-demographic and urban planning variables with the distribution of different types of food stores, found that FSA level measures were robust to define neighborhoods throughout British Columbia. Furthermore, one of the few Canadian studies that assessed the association of the food environment and chronic disease, Alter *et al.* (68), used FSA to define neighbourhoods as well.

4.2.1.2 Classification of Food Stores

Standard Industrial Classification (SIC) codes were used to differentiate and classify the majority of food outlets. SIC codes themselves are designed to categorize food outlets into functional groups representing the types of the services they provide and are commonly used by Statistics Canada and other organizations to facilitate the collection and analysis of business and industry data. The majority of studies have used 8-digit SIC codes to differentiate restaurant types and services. However, the 2011 CFM Leads dataset only provided 6-digit SIC codes and names, which do not allow for a clear differentiation between types of stores, such as full-service and fast-food restaurants. Due to misclassification errors during data collection and compilation, the reliance on solely SIC codes can also fail to fully encompass the construct definitions that differentiate the services these food stores provide and the corresponding categorization. For example, a study by Currie *et al.* (431) found a positive association between the availability of chain fast-food restaurants and obesity, however no associations were seen when only SIC codes were used to classify fast-food restaurants. In order to reduce misclassification errors, two additional methods of categorization were used: annual sales volumes and employee counts, both of which have been used in similar studies (140,387,431–433). From the CFM Leads database, 9 unique 4-digit SIC codes were identified as food providers. Combined with the additional 2-digit sub-codes, a total of 34 different food outlets types were identified.

4.2.1.3 Differentiation of Fast-food and Full-service Restaurants

The first categorization was to differentiate between fast-food and full-service restaurants. For this thesis, the “2011 Directory of Restaurants & Fast-food Chains in Canada” was used to identify the major restaurant chains within Canada. The directory provided up to date information of the names and the number of restaurants across provinces in Canada. The entire CFM Leads dataset was used to identify major chains in order to reduce the influence of misclassification errors during its compilation. In order to differentiate between fast-food and full-service restaurants, locations within the directory were recorded and classified using the following definitions. While there is a general acceptable notion of what constitutes a “fast-food” restaurant, there is no formal definition available. There have been a variety of ways that studies have classified restaurants into “fast-food” (27,28). For the sake of this study, a fast-food restaurant was defined as a location that offered take-away food, customers paid before eating, had limited or no table service, had limited furnishing, or food is consumed on or near the premises or takeout (95,434). A full-service restaurant was defined as a food outlet that offered table service or waiter service where customers paid after eating, a seating area where food is consumed on premise and alcohol service (435,436). All relevant locations within the directory were identified by name using the STATA 12 rename function and were manually searched for any misspelled locations and misclassifications within the CFM Leads dataset.

Using the 2011 Directory of Restaurants & Fast-food Chains in Canada, 286 individual fast-food chains were defined as fast-food restaurants. In order to create a better definition of fast-food restaurants, pizza places and pizzerias were also included in this list. These locations were identified using 2 methods. The first was through using the SIC code 5812-22 “pizza”. The second was by searching the CFM Leads data holding for any food outlets with “pizza” or “pizzeria” within its name that was not already classified as either a fast-food or full-service restaurant. The SIC codes Carry Out (5812-06) and Restaurants-Food Delivery (5812-30) were also classified as fast-food locations as these location are likely to provide fast-food, a method used in similar studies (434). A total of 23683 locations were found.

Using the 2011 Directory of Restaurants & Fast-food Chains in Canada, 219 full-service restaurants chains were identified from the CFM Leads dataset. All relevant establishments within the SIC 5812 that did not meet the criteria for fast-food and full-service restaurants chains and were not named within the retail directory were classified as “Local and Non-chain Restaurants.” These locations could not be accurately differentiated between fast-food or full-service. This group comprised a large number of the observable food outlets. Thus, the food-service environment was broken into three components. Fast-food and full-service restaurant chains are the primary components of interest, with all non-defined food-service establishments being redefined as local and non-chain restaurants for ease of discussion. A total of 3791 full service restaurants, and 48612 local and non-chain restaurants were found.

4.2.1.4 Supermarkets, Medium Sized Grocery Stores, and Small Grocery Stores and Convenience Stores

The second categorization was to differentiate supermarkets and large grocery stores, intermediate grocery stores, and small grocery stores and conveniences stores. In order to identify major chain supermarket and large grocery store locations, the Foods-Grocery section within the “2011 Directory of Retail Chains in Canada” was used. The directory provided up to date information of the names, traits, and counts of recognized franchised grocery store locations across Canada, allowing for accurate identification of supermarkets as compared to using solely SIC codes. All relevant locations within the directory were identified by name using the STATA 12 rename function as well as manually searched within the dataset for any misspelled variations in names that may exist within the CFM Leads dataset. In order to prevent possible locations from being excluded from the analysis due to misclassification errors, the entire dataset was searched in order identify major chains locations.

Although the directory allowed the identification of locations of franchised supermarket and grocery chains, the size of these food outlets can differ by geographic location and population size. Store size can greatly influence the type of services these locations are able to provide, limiting the available food stock and influencing food price. Therefore, in order to further increase the accuracy of the supermarket and large grocery store measure, an additional cutoff of an annual sales volume of at least $2.5 million was used. Many studies have used a similar sales cutoff to categorize supermarkets; however the majority of studies used a cutoff of $2 million to categorize supermarkets (92,437,438). Due to the categorical nature of the sales volume data reported in the CFM Leads database, only a cutoff of $2.5 million was feasible. A total number of 2933 locations were found.

Small and intermediate grocery stores were classified using the remaining food stores within the SIC codes 5411-04, Food Product-Retail, and 5411-05, Grocers-Retail, after excluding the supermarkets and large grocery stores (393,439). A food outlet was categorized as a small grocery store if it had an annual sales volume of less than $1 million and total employee count of less than 5 individuals (47). Using a combination of both annual sales volumes and employee count data provided a more robust categorization of food stores compared to solely using SIC codes, a methodology that has been used in the literature (101,393,439,440). Furthermore, the recent introduction of automated cashiers may result in smaller employee counts, making the use of solely employee count unreliable. Small grocery stores were further paired with convenience stores as it is difficult to draw a categorical distinction between the two food outlets.

Smaller grocery store locations, due to their limited space, tend to sell larger amounts of energy-dense unhealthy food choices and limited and more expensive healthy food choices, akin to convenience store (47), and both have been associated with negative health outcomes (441). Convenience stores were classified using solely the SIC codes 5331-01 (Variety Stores), 5411-02 (Snack Stores), and 5411-03 (Convenience Stores). A total of 6296 small grocery stores and 7764 convenience stores were found.

All establishments within the SIC codes 5411-04 and 5411-05 that did not meet the criteria for either small grocery stores or were not identified as supermarket and large grocery store chains through the directory were classified as “Intermediate Grocery Stores”. With these locations it could not be identified what kinds of food products and services they provide, limiting the ability to accurately measure their distinct effects on health. Furthermore, the association of these medium sized grocery stores are mixed in the literature, with many studies finding no associations or limited health benefits (50,53,55,56). A total of 7710 intermediate grocery stores were found.

4.3 Outcome Measures

Three chronic disease variables were available in the CCHS and included in the analysis.

Type II Diabetes: Diabetes prevalence was ascertained using the diabetes type derived variable (CCCDDIA) in the CCHS. CCCDDIA was determined through 7 diabetes related questions: CCC_10B (diabetes diagnosed when respondent was not pregnant), CCC_10C (when was insulin intake started), CCC_101 (has diabetes), CCC_102 (age of diabetes diagnosis), CCC_105 (currently taking insulin), CCC_106 (currently taking pills to manage blood sugar levels) and DHH_AGE (age), with the response from each question being combined and grouped. Respondents were asked to keep in mind that the survey was interested in conditions that been diagnosed by a health professionals when answering these questions. The derived variable was then organized into 5 groups: type I diabetes (CCCDDIA=1), type II diabetes (CCCDDIA=2), gestational diabetes (CCCDDIA=3), could not be classified (CCCDDIA=4), and not applicable

(CCCDDIA=6). For the sake of this study, only type II diabetes was of interest. As a result, type I diabetes (CCCDDIA=1), gestational diabetes (CCCDDIA=3), and could not be classified (CCCDDIA=4) were removed from the study population. The remaining two groups were then recategorized into a dichotomous variable: one if presence of type II diabetes (CCCDDIA=2) and zero if absence of diabetes ((CCCDDIA=6)).

Cardiovascular Disease Prevalence: The prevalence of cardiovascular disease was determined from variable CCC_121 in the CCHS, which asked the question “Do you have heart disease?” Respondents were asked to keep in mind that the survey was interested in conditions that been diagnosed by a health professional. From this variable, a dichotomous variable was created using two distinct groups: those that had a cardiovascular condition (CCC_121=1) and those who did not (CCC_121=2). Three irrelevant response groups were removed from the study population: Don’t Know (CCC_121=7), Refusal to Answer (CCC_121=8), and Not Stated (CCC_121=9).

Hypertension Prevalence: Hypertension prevalence was determined using the variable CCC_071 in the CCHS, which asked the question “Do you have high blood pressure?” Respondents were asked to keep in mind that the survey was interested in conditions that been diagnosed by a health professional. From this variable, a dichotomous variable was created using two distinct groups: individuals that had high blood pressure (CCC_071=1) and those who did not (CCC_071=2). Three irrelevant response categories were removed from the study population: Don’t Know (CCC_071=7), Refusal (CCC_071=8), and Not Stated (CCC_071=9).

4.4 Potential Mediators

Body Mass Index (BMI): BMI, coded as HWTDISW, was a derived variable in the CCHS. HWTDISW was constructed using two other variable, self-reported weight (HWTWTK), measured in kilograms, divided by the square of self-reported height (HWTHTM), measured in metres. However, individuals tend to over report their height and under report their weight, leading to biased estimates of BMI (442). In order to correct for this bias, validated gender-specific correction factors generated by Gorber *et al.* (443) were used. The relevant correction factors are:

$$\boldsymbol{BMI_{(Male)} = -1.08 + 1.08*BMI_{(self\text{-}reported)}}$$

$$\boldsymbol{BMI_{(Female)} = -0.12 + 1.05*BMI_{(self\text{-}reported)}}$$

BMI was further categorized into three additional groups using guidelines defined by the World Health Organization. Individuals with a BMI of less than 25 were grouped as under and normal weight, a BMI of between 25 and 30 as overweight, and greater than 30 as obese (444).

Fruits & vegetables Consumption: Daily consumption of fruits and vegetables was used as a proxy for daily dietary pattern, measured through the derived daily frequency of total consumption of fruits and vegetables (FVCGTOT). The variable was constructed through the sum of 6 fruits & vegetables related questions: FVCDJUI (daily juice consumption), FVCDFRU (daily fruit consumption), FVCDSAL (daily green salad consumption), FVCDPOT (daily potato consumption), FVCDCAR (daily carrot consumption), and FVCDVEG (daily other vegetable consumption), which asked the respondents to list their total one day intake for each food category. FVCGTOT was then further reorganized into two predetermined groups based on the total number of consumed servings: low daily fruits & vegetables consumption (less than 5 times/servings per day) and medium to high daily fruits & vegetables consumption (greater than 5 times/servings per day). A cutoff of 5 servings of fruits & vegetables was used reflecting the recommendations by the Canada Food Guide as well as Canadian assessments of diet quality (337,445,446). Participants that did not provide data were listed as missing from the study (FVCGTOT=9)

Physical Activity: Physical activity was measured using the Leisure and Transportation Physical Activity Index (PACDLTI). PACDLTI was derived in the CCHS by categorizing the variable “Total Daily Energy Expenditure: Transportation and Leisure Physical Activity” (PACDTLE) into 3 functional groups. These groups represented increasing levels of daily physical activity, categorizing participants as physically active

(PACDLTI=1), moderately physically active (PACDLTI=2), or physically inactive (PACDLTI=3). Individuals who did not state their activity levels (PACDLTI=9) were removed from the analysis.

4.5 Confounders and Covariates

The section below outlines the methodology used in order to construct the variables included within the analysis. Tables outlining the creation of the variables are available in **Appendix A**.

4.5.1 Demographic Variables

Age: Age was constructed as a continuous variable derived through 3 self-reported questions within the CCHS: date of birth (DHH_DOB), month of birth (DHH_MOB) and year of birth (DHH_YOB). These constructed ages were then confirmed with the respondents to ensure reliability. In order to limit the study population to relevant participants, age restrictions were applied to capture those that were most likely to have a chronic disease. In this study, age was excluded if they were under 35 years of age and over 75 years of age. An age squared variable was also constructed in order to account for the quadratic effect of age that was seen in the literature.

Sex: Sex was determined through the variable DHH_SEX within the CCHS, which asked "Is the respondent male or female?" Individuals were then coded as either male (DHH_SEX=1) or female (DHH_SEX=2), based on their response. There were no missing responses.

Immigrant status: Immigration status and duration was determined using two variables within the CCHS. The first was using immigrant status (SDCFIMM), which differentiated CCHS participants between Canadian born citizens (SDCFIMM =2) or immigrants (SDCFIMM =1). Due to the healthy immigrant and acculturation effects, immigrants were further categorized into 2 groups based on the length of residency (SDCGRES): a length of residency of 10 years or less and a length of residency of 11 years or more.

Race/Ethnicity: Race and ethnicity was determined using the cultural or racial origin derived variable (SDCDCGT) in the CCHS. This variable was constructed through a combination of 13 individual questions that asked about cultural descent, asking if the participant was Caucasian (SDC_43A), Chinese (SDC_43B), South Asian (SDC_43C), African American (SDC_43D), Filipino (SDC_43E), Latin American (SDC_43F), South East Asian (SDC_43G), Arab (SDC_43H), West Asian (SDC_43I), Japanese (SDC_43J), Korean (SDC_43K), or of other racial origins (SDC_43L and SDC_43M). Due to limitations in cell counts of some ethnic groups within FSAs in Canada, assessing the effects of individual races was not feasible. As a result, race was dichotomized into two broad groups, individuals who were of Caucasian decent (SDCDCGT=1) and visible minorities, which was composed by grouping all other race responses into a single category (SDCDCGT=2,3,4,5,6,7,8,9,10,11,12,13). Those not applicable (SDCDCGT=96) and not stated (SDCDCGT=99) were removed from the analysis.

4.5.2 Socioeconomic Variables

Marital Status: The participant's marital status, coded as DHH_MS in the CCHS, was determined through the question "What is your marital status? Are you married, living in common law, widowed, separated, divorced, or single, never married?" In order to avoid small sample size within FSAs, marital status was re-categorized into 3 broad groups. The first was married (DHH_MS=1) and living with partner/common-law (DHH_MS=2) individuals. The second was composed of widowed (DHH_MS=3), separated (DHH_MS=4), and divorced (DHH_MS=5) individuals. The third, single/never married (DHH_MS=6), was used as the reference group. Participants who did not know their marital status (DHH_MS=97) or refused to answer (DHH_MS=98) were removed from the analysis.

Education Level: Education level was determined through the highest level of individual level educational achievement question in the CCHS (EDUDR04). EDUDR04 was constructed by combining the responses from 4 variables: EDU_1, which asked what is the highest grade of elementary or high school the participants completed, EDU_2, which asked did the participants graduated from high school, EDU_3, which asked have if the participants received any other education that could be counted towards a degree, certificate, or diploma from an educational institution, and EDU_4, which asked the highest degree, certificate, or diploma the participants had obtained. Using responses to these questions, individuals were then categorized into 4 groups based on their level of academic achievement: less than secondary school (EDUDR04=1), secondary school graduation (EDUDR04=2), some post-secondary (EDUDR04=3) and post-secondary graduation (EDUDR04=4). Participants that did not state their education level were removed from the analysis (EDUDR04=9).

Income: The total household income distribution (INCDRCA) variable was used in this study. INCDRCA was derived by categorizing the distribution of the adjusted household income ratio (INCDADR) across all participants in the survey into deciles. In order to have reasonable sample size within smaller FSAs and reduce the number of categories, the deciles were collapsed into quintiles, with decile 1 and 2 being collapsed into quintile 1 (INCDRCA=1 & INCDRCA=2), decile 3 and 4 being collapsed into quintile 2 (INCDRCA=3 & INCDRCA=4), decile 5 and 6 being collapsed into quintile 3 (INCDRCA=5 & INCDRCA=6), decile 7 and 8 being collapsed into quintile 4 (INCDRCA=7 & INCDRCA=8), and decile 9 and 10 being collapsed into quintile 5 (INCDRCA=9 & INCDRCA=10). Those not applicable (INCDRCA =96) and not stated (INCDRCA=99) were removed from the analysis.

4.5.3 Lifestyle Variables

Smoking: Smoking status was ascertained through the type smoker (SMKDSTY) variable derived in the CCHS. The measure was constructed using 4 variables: whether the respondents had smoked a whole cigarette (SMK_01B), the type of smoker (SMK_202), has smoked 100 or more cigarettes (SMK_01A), and smoked cigarettes daily (SMK_05D). These variables were categorized into 4 groups: daily smokers (SMKDSTY=1), occasional smokers (SMKDSTY=2 and SMKDSTY=3), former smokers (SMKDSTY=4 and SMKDSTY=5), and never smokers (SMKDSTY=6). Occasional smokers were defined as smokers that were formerly or never daily smokers or a smoker that has smoked less than 100 cigarettes in their lifetime. Former daily smokers were defined as current non-smokers or smokers that had at least 1 whole cigarette in their lifetime. Individuals who did not state their smoking status (SMKDSTY=99) were removed from the analysis.

Alcohol Consumption*:* Alcohol consumption was derived using the type of drinker (12 months) variable (ALCDTTM) within the CCHS. ALCDTTM was derived based on variables ALC_1 (Drank alcohol in the past 12 months) and ALC_2 (frequency of drinking alcohol per month). ALCDTTM was categorized into 3 groups for the study: regular drinkers (ALCDTTM=1), occasional (ALCDTTM=2), and nondrinkers (ALCDTTM=3). Regular drinking was defined as the consumption at least 2 or more alcoholic drinks. Occasional drinking was defined as the consumption of 1 alcoholic beverage per month. Nondrinkers were defined as participants that had not had a drink in the last 12 months. Individuals who did not state their drinking status (ALCDTTM=9) were removed from the study population.

4.5.4 Neighbourhood Level Covariates

Neighbourhood Ethnicity: Using the 2011 Census NHS, neighbourhood ethnicity was calculated as the weighted proportion of visible minorities within each FSA. The total number of visible minorities per FSA was derived using responses to Question 18, which asked respondents if they belong to an Aboriginal group, and Question 19, which asked respondents to mark one or more of the following responses according to their racial background: White, South Asian, Chinese, Black, Filipino, Latin American, Arab, Southeast Asian, West Asian, Korean and Japanese. To calculate the proportion, the total number of individuals who identified as visible minorities were then divided by the number of total respondents to both questions. Response counts were weighted to reflect FSA population counts through the use of population estimates from the 2011 Census.

Neighbourhood Income: Neighbourhood income was defined as the prevalence of low income individuals between the ages of 18 and 64 in 2010 within each FSA, a derived variable found with the 2011 NHS. Low income status was determined using a Low Income Measure After-Tax (LIM-AT). LIM-AT is a low income line set a fixed percentage based on the median adjusted total after tax incomes of households or individuals across Canada. The adjusted total after tax income is the total income remaining after taking into account the needs and cost of an individual and/or household. Prevalence of low incomes individuals per FSA was provided as a weighted percentage based on survey response rates and was taken directly from the NHS.

Neighbourhood Education: Neighbourhood Education was obtained using the derived variable "Highest certificate, diploma or degree" within the Education section of the 2011 NHS. This variable was constructed using the responses to 4 questions: Question 27, which asked if the survey respondents had a secondary (high) school diploma or equivalent, Question 28, which asked if the survey respondents had a registered apprenticeship or other trades certificate or diploma, Question 29, which asked if the survey respondents had a college, CEGEP or other non-university certificate or diploma, and Question 30, which asked if the survey respondents had a university certificate, diploma, or degree. Using this information, the survey provided FSA level counts of the highest level of education achieved by individuals between the ages of 25 and 64. For the sake of this thesis, neighbourhood education was calculated as the proportion of individuals with only a high school diploma or less within each FSA. FSA counts on the number of individuals with no education related degrees and individual with only a high school diploma were combined and then divided by the total number of survey response to the 4 questions above, with the response counts being weighted using 2011 Census FSA population counts to reflect population level data.

Transportation: No direct measures of the modes of transportation were found in the available datasets. Hence the mode of transportation used to travel to work, available in the 2011 NHS was used as a proxy. Data on the mode of transportation was available through Question 47(a), which asked the survey participants how they "*usually*" got to work. Participants were able to select one of the following options: car, truck or van - as a driver; car, truck or van - as a passenger; bus, subway or elevated rail, light rail, streetcar or commuter train, passenger ferry, walked to work, bicycle, motorcycle, scooter or moped, and additional Other option. The transportation variable defined in this study was used as the proportion of individuals that traveled to work using a car, truck, or van per FSA. FSA counts on the number of individuals that traveled to work using a car, truck, or van as either a driver or passenger were combined and then divided by the total number of survey response to question 47(a) , with the response counts being weighted using 2011 Census FSA population counts.

Population Density: Population density was calculated by dividing the 2011 Census FSA Population counts by the 2011 Census FSA Total km^2 Area data, with the measure representing the total number of individual per km^2 within each FSA.

4.6 Study Population

From the respondents of the CCHS, a number of inclusion and exclusion criteria were applied in order to create a relevant study population. Age was restricted to adults between the ages of 35 and 75, as individuals within this age group are at the greatest risk of developing chronic conditions. Individuals residing within the Territories were also excluded as, due to a combination of their lower population size and large geographic area, individuals living in these areas tend to have inherent differences in their socio-demographic and lifestyle characteristics compared to the rest of Canada. Respondents who were pregnant were removed as these individual tend to have differences in their risk of developing chronic disease, BMI, and dietary patterns. Extreme BMI values, ranging from less than 10 and greater than 70, were also removed from the study as they are probable outliers, with similar cutoffs used in other studies (99,447,448).

A major exclusion criterion used for this study was urbanicity, with individuals living in rural areas being excluded from the study population. Rurality was used an exclusion criteria due to distinct dissimilarities in urban planning and development, available modes of transportation, population densities, and accessibility to food stores seen between rural and urban neighbourhoods. These differences result in individuals in rural areas seeing an increased demand in transportation and time needed to access food stores (221) , reduced access to supermarkets, and dependence on small food stores and convenience stores (89).

A study by Healy & Gilliand (87) found that in rural neighbourhoods the use of area level measures and postal codes as a proxy for neighbourhoods resulted in unreliable and inaccurate measures of exposure to food environment due to their vast size and limited store accessibility (87). Furthermore, the collection of food outlet data within secondary databases in rural areas has been found to be inaccurate and incomplete compared to their urban counterparts (96,179). Due to these limitations, rural areas were excluded from the analysis, an approach used in other studies (101,432,433,449). In order to identify individuals living in rural area, the CCHS variable geodpsz, a five level categorical variable classifying different levels of urbanicity, was used. The individuals defined in the first level, categorized as a "Rural Areas" within the CCHS, were removed, while the other 4 levels were grouped into a single Urban category.

In order to adjust for missing values within the CCHS, a missing-indicator variable was constructed. Two dummy variables were created as missing indicators to adjust the initial population, with missing values being assigned a 1.. Both of these variables employed a list wise deletion approach for missing values under the assumption that missing data in the survey was missing at random (MAR). Under this assumption, any systematic differences between the missing values and the observed values within the study population can be explained through other variables included within the analysis (450). The MissingCon variable was constructed if no responses were provided for any of the demographic confounders (gender, length of residency, age, and age^{2}), socioeconomic confounders (education level, income quintile, and marital status), or neighbourhood level covariates (the proportion of visible minorities per FSA, the prevalence of low income per FSA, proportion of individual that drive to work per FSA, proportion of individual with high school education or less per FSA). MissingCon was only used when potentially mediating and lifestyle confounders were excluded from the analyses. The second variable, MissingConLife, incorporated both the lifestyle variables and potential mediators in its construction (smoking status, type of drinker, weight class, fruits & vegetables consumption, and physical activity levels), and was the population used for the majority of analyses in this thesis.

In general, diagnostics for multicollinearity were not conducted for the confounders and covariates within the analyses as the significance of these variables within the causal pathway was outlined in the literature review. However, during the analysis, a large correlation between ethnicity and length of residency was seen, suggesting that both variables captured comparable constructs. As a result, ethnicity was dropped as a potential confounder and instead was used at the neighbourhood level.

This implementation of these cutoff and associated adjustments in sample size are outlined in Table 4.1.

Table 4.1 Creation of Sample Population

Data Cleaning	
Sample	**N**
CCHS 2009-2010	124,870
Age (35-75 years)	78,512
BMI + Pregnancy	71,055
Rural +Territories	49,341
Merging with Food Outlet and Neighbourhood level data	49,195
Missing Variables	
Sample	**N**
Demographic, Socioeconomic, and Neighbourhood Level Confounders	42,323
Demographic, Socioeconomic, and Neighbourhood Level Confounders + Lifestyle Confounders and Potential Mediators	40,902

4.7 Data Analysis and Implementation

All data management, cleaning, and statistical analyses were conducted using the statistical program STATA 12 (451). This included the merging of all relevant datasets into a single data set, applying inclusion/exclusion criteria to the study population, the selection and recoding of all variables, and all univariable, multivariable, and mediation analyses.

4.7.1 Subgroup analysis

In the analysis, sex was considered an effect measure modifier. Effect measure modification occurs due to differences in the observed associations between the exposure and outcome across select sub-populations in the study population. Support for this claim was outlined throughout the literature review, with differences in how socioeconomic, biological, demographic, and lifestyle determinants of the food environment, obesity, and chronic disease differed between males and females. Therefore, in order to adjust for these inherent differences between the sexes, the descriptive, multivariate, and Baron and Kenny analyses were all stratified by males and females in addition to being conducted for the overall study population.

4.7.2 Statistical Analyses

4.7.2.1 Descriptive Analyses

Descriptive statistics were produced separately for the overall population and for both males and females. Sampling weights provided by Statistics Canada were used for these analyses. For each of the population groups, a single descriptive table was created, with the sample population being derived through the MissingConLife variable. The primary table included all density measures for the food environment (both population and area level densities measures of supermarkets, intermediate grocery stores, small grocery and convenience stores, fast-food restaurants, full-service restaurants, and non-chain and local restaurants), the prevalence of the three main chronic conditions (diabetes, cardiovascular disease and hypertension prevalence), demographic confounders (sex, length of residency, age, and age^2), socioeconomic confounders (education level, income quintile, and marital status), neighbourhood level covariates at the FSA level (the proportion of visible minorities, the prevalence of low income, proportion of individual that drive to work, proportion of individual with high school education or less), and lifestyle variables and potential mediators (smoking status, type of drinker, weight class, fruits & vegetables consumption and physical activity levels). For the categorical variables, frequencies and percentages were provided, while means and standard deviations were produced for the continuous variables. Additional cross tabulations between the measures of the food environment and the prevalence of the chronic conditions were also conducted. These tables provided means and standard deviations for the number of food outlets per FSA for individuals with and without the prevalence of the chronic disease outcomes. Separate cross-tabulations were also produced for males and females, with the study population being defined using the MissingConLife variable.

4.7.2.2 Multivariable Analysis

In order to assess the association between the food environment and chronic disease prevalence, a modified Poisson regression with robust standard errors was used (452). A modified Poisson regression model with robust option in Stata uses a sandwich variance estimator to calculate estimates of the incidence risk ratio (IRR) with standard errors that accounts for clustering of the observations at the FSA level (453). These IRRs estimates are equivalent to relative risk ratios (RR), and have been found to provide a robust estimate of the relative risk (RR) compared to logistic regression and log-binomial regression models (454,455).

As the outcomes measures were dichotomous, either a modified Poisson regression or logistic regression may have been used. However, only when the rare disease assumption is met, defined as the outcome being present in less than 10% of the sample population, does an odds ratio (OR) estimate the relative risk. When the rarity assumption is not met, the odds ratio, calculated using logistic regression, provides an inflated estimate of the relative risk, leading to misleading conclusions (456). One of the outcome measures, hypertension, did not meet the requirements for the rare disease assumption. As the modified Poisson regression can estimate relative risk regardless of rarity, it was the preferred method for the multivariable analysis. Furthermore, the use of relative risk ratio over odds ratio in cross sectional studies has been supported in the literature (457), as the relative risk is able to provide consistent covariate-adjusted estimates of the average effect compared to odds ratios (453). Modified Poisson regression was also used in two of the reviewed studies that assessed the relationship between the food environment and chronic disease (62,66) with one of these being conducted in a Canadian setting (66). However, as the data are cross-sectional in this study, the lack of temporality makes estimating incidence infeasible. As a result, estimates from the regression models are not reflective of the relative risk but instead of the relative prevalence (RP) and prevalence ratios (PR). To properly interpret the results, I used the term "relative prevalence" rather than the "relative risk" to reflect the true association being estimated.

In order to examine the association between the food environment and the prevalence of chronic disease, three separate regression models were used. The first model (Model 1) assessed the association between all 6 food store outlets and the prevalence of type II diabetes, cardiovascular disease, and hypertension without adjusting for any potential confounders or mediators. The second model (Model 2) adjusted for the demographic, socioeconomic, and neighbourhood level confounders discussed in the conceptual framework. The study population in these models were limited by the MissingCon variable. The final model (Model 3) built upon the second model, adjusting for potential mediators, BMI, dietary patterns, and physical activity, and lifestyle confounders, smoking status and type of drinker. The study populations in these analyses were limited by the MissingConLife variable. A separate model was used to adjust for potential mediators and lifestyle variables as the effect of these variables on the association between the food environment and chronic diseases prevalence remains ambiguous in the literature. As these variables could be either confounders or mediators in the casual pathway, adjusting for them separately allows for a better assessment and comparison of results in the literature.

Multivariable analyses were conducted both for the overall population and stratified by sex. Survey sampling weights were applied in all descriptive and regression analysis.

4.7.2.3 Mediation Analyses

The role of the potential mediators BMI, dietary patterns, and physical activity in the causal pathway between the food environment and chronic disease prevalence, the secondary objective of the thesis, was examined using the Baron and Kenny mediation approach (458).

According to the Baron and Kenny method, mediation can be assessed through the stepwise implementation of 4 steps through regression analyses as follows:

1) The measures of the food environment (exposure) are significantly associated with chronic disease prevalence (outcome). This step establishes that there is an association between the exposure and outcome that may be mediated.

2) The measures of the food environment (exposure) are significantly associated with each of the potential mediators (BMI, dietary patterns, and physical activity). This step treats the mediators as an outcome variable, establishing the exposure predicts the mediators.

3) Each of the potential mediators (BMI, dietary patterns, and physical activity) predict chronic disease prevalence (outcome) while adjusting for the food environment (exposure). This step establishes that the mediator is predictive of the outcome. The exposure must be adjusted for when assessing this association as both the outcome and

mediator may be separately predicted by the exposure measure. Failing to adjust for these associations could lead to a false rejection of the null hypothesis for mediation.

4) The association between the food environment (exposure) and chronic disease prevalence (outcome) is attenuated after adjusting the model for the potential mediator (i.e. the estimates between the food environment and chronic disease in Step 1 are attenuated relative to the association in Step 3).

Through the stepwise assessment of each of these steps, 3 types of mediation can be inferred. If Steps 1 through 3 are found to be significant and step 4 finds a complete attenuation of the relationship between the exposure and outcome, with the association between the two variables becoming zero, complete mediation can be inferred. If steps 1 through 3 are met, however only a partial or no attenuation is seen in step 4, partial mediation is implied. Partial mediation occurs when, although mediation exists in the causal pathway, some sort of direct relationship still persists between the independent and dependent variable. No mediation is confirmed when no significant associations were found in either step 1, 2, or 3, in that sequential order (459).

For all the steps in the Baron and Kenny criterion, a modified Poisson regression was used in order to assess the association between the food environment, chronic disease prevalence and the potential mediators. Furthermore, mediation analyses were conducted for both the overall study population and as stratified by sex, with probability survey weights being used. Steps 1, 3, and 4 of the Baron and Kenny analysis were also adjusted for potential confounders and covariates. These variables, however, were excluded from Step 2. The majority of these confounders and covariates were included in the analysis due to their role in the casual pathway between the food environment and chronic disease as found in the literature. However, these covariates may not play a similar role in the relationship between the food environment and these mediators, limiting their effectiveness if adjusted for.

One of the major caveats of using the Baron and Kenny method is the low statistical power of the test. However, due to the large sample size of study population, this is non-issue in this analysis (460). Also note that multiple exposures measures were assessed in each of the Baron and Kenny regressions. Although methods such as structural equation modeling (SEM) are better able to assess these mediations, the Baron and Kenny approach is still relevant, albeit slightly less accurate (459).

Chapter 5

5 Results

5.1 Descriptive Analysis

5.1.1 Continuous and Categorical Variables

The descriptive characteristics of the study population are reported in Table 5.1 and Table 5.2. Of the population based food environment measures, the mean density of supermarkets and large grocery stores, intermediate grocery stores, and small grocery and convenience stores per 10,000 individuals were 0.688, 2.148, and 4.052, respectively. Compared to the other population based density measures, the most prevalent types of food outlets were fast-food restaurants and local and non-chain restaurants, with a mean density of 7.524 and 13.647 outlets per 10,000 individuals. Compared to the other restaurant measures, the availability of full-service restaurants per FSA was limited, with only 1.244 outlets per 10,000 individuals. Similar trends were seen with the area based food environment measures, with mean densities of 0.095 supermarkets and large grocery stores, 0.4115 intermediate grocery stores, 0.948 small grocery stores and convenience stores, 1.428 fast-food restaurants, 0.232 full-service restaurants, and 3.191 local and non-chain restaurants per km^2 being observed within each FSA. A slight discrepancy was also seen between sex and both density measures, with females typically having a slightly higher mean number of fast-food and full-service restaurants in their surrounding food environment, while males experienced a higher mean number of local and non-chain restaurants. While in the overall population the majority of individuals consumed less than 5 daily servings of fruits and vegetables (56.7%), when stratified for gender, it was much higher in men (64.3%), with females more frequently consuming 5 or more daily servings of fruits and vegetables (51.2%). The majority of the respondents were physically inactive (48.245%), with similar trends being seen between both genders (males: 46.2%; females: 50.3%).

In terms of individual level characteristics, the average age of the study population was 51.58, with 49.3% of the sample being female while 50.7% was male. Both type II diabetes and cardiovascular disease were prevalent in less than 10% of the population; with 7.4% of the sample self-reporting types II diabetes, while 5.1 % reported cardiovascular disease. Hypertension prevalence was much higher, with hypertension being reported in 21.4% of the population. A disparity in chronic disease prevalence was seen between sexes as well, with males having higher frequencies of disease prevalence. Diabetes prevalence was reported 8.8% for men compared to 5.9% for women, while cardiovascular disease prevalence was in 6.4% for men but only 3.8% for women. Similarly, hypertension prevalence was reported within 22.1% for men compared to 20.7% for women.

The majority of sample was comprised of Canadian residents (73.7%), who were married (73.7%), had completed post-secondary education (66.3%), regularly consumed alcohol (66.7%), and either formerly smoked (44.0%) or never had smoked (34.7%). At the neighbourhood level, the average population density per FSA was 1980 individuals per km^2, with an average visible minority composition of 21.2% per FSA. Low income prevalence was limited to an average of 14.5%, while an average of 78.0% of individuals drove to work. These frequencies were similar between sexes.

Table 5.1 Descriptive Statistics of Continuous Variables

Variable	Weighted Mean (SD)		
	Overall	Male	Female
Population Based Density Measures (the number of locations per 10000 individuals per FSA)			
Supermarket and Large Grocery Stores	0.688 (0.613)	0.685 (0.611)	0.692 (0.616)
Intermediate Grocery Stores	2.148 (1.673)	2.149 (1.69)	2.148 (1.655)
Small Grocery and Convenience Stores	4.052 (2.914)	4.053 (2.901)	4.052 (2.926)
Fast-food Restaurants	7.524 (5.015)	7.450 (5.004)	7.601 (5.026)
Full-service Restaurants	1.244 (1.378)	1.233 (1.372)	1.256 (1.384)
Local and Non-chain Restaurants	13.647 (12.315)	13.813 (12.631)	13.475 (11.979)
Area Based Density Measures (the number of locations per km^2 per FSA)			
Supermarket	0.095 (0.141)	0.095 (0.141)	0.095 (0.14)
Intermediate Grocery Stores	0.415 (0.721)	0.419 (0.741)	0.408 (0.7)
Small Grocery and Convenience Stores	0.948 (1.758)	0.949 (1.742)	0.947 (1.775)
Fast-food Restaurants	1.428 (2.159)	1.407 (2.098)	1.451 (2.219)
Full-service Restaurants	0.232 (0.437)	0.226 (0.435)	0.236 (0.439)
Local and Non-chain Restaurants	3.191 (7.209)	3.276 (7.559)	3.088 (6.829)

Demographic Confounders			
Age	51.581 (10.541)	51.457 (10.471)	51.709 (10.611)
Neighbourhood level Covariates			
Percentage of Visual Minorities per FSA	21.197 (21.385)	21.463 (21.499)	20.924 (21.265)
Percentage of Low Income Prevalence per FSA	14.467 (6.745)	14.499 (6.846)	14.434 (6.64)
Percentage of Individuals with a High School Diplomas or Less per FSA	34.277 (9.947)	34.317 (10.074)	34.236 (9.816)
Percentage of Individuals that Drive to Work per FSA	78.029 (15.409)	77.757 (15.675)	78.309 (15.126)
Population Density (Individuals per km^2)	1979.913 (2489.577)	2026.341 (2616.897)	1932.156 (2350.542)

Table 5.2 Descriptive Statistics of Categorical Variables

	Weighted Frequencies (%)		
Variable	Overall	Male	Female
Chronic Disease			
Type II Diabetes Prevalence			
Diabetes	7.400	8.822	5.936
No Diabetes	92.600	91.178	94.064
Cardiovascular Disease Prevalence			
Cardiovascular Disease	5.083	6.374	3.754
No Cardiovascular Disease	94.917	93.626	96.246
Hypertension Prevalence			
Hypertension	21.425	22.145	20.686
No Hypertension	78.575	77.855	79.314
Demographic Confounders			
Gender			
Female	49.295		
Male	50.705		
Immigration Status/Length of Residency			
Canadian-born	72.141	71.401	72.903
Length of Residency: 1 to 10 years	6.143	6.680	5.591
Length of Residency: +10 years	21.715	21.919	21.506
Socioeconomic Confounders			
Marital Status			
Married	73.689	77.919	69.338
Single	10.795	11.052	10.530

Widowed/Separated/ Divorced	15.516	11.029	20.132
Education Level			
Less than High School	11.831	11.609	12.059
High School Diploma	15.930	14.944	16.945
Incomplete Postsecondary Education	5.891	5.567	6.224
Completed Postsecondary Education	66.348	67.880	64.772
Income Quintile			
Quintile 1	18.996	16.616	21.443
Quintile 2	19.579	18.026	21.177
Quintile 3	19.720	19.760	19.680
Quintile 4	20.804	22.085	19.486
Quintile 5	20.902	23.514	18.214
Potential Mediators			
Weight Class			
Under and Normal Weight	32.248	22.752	42.014
Overweight	40.789	48.372	32.990
Obese	26.963	28.875	24.996
Fruits & vegetables Consumption			
Less than 5 Daily Servings	56.659	64.340	48.759
5 or More Daily Servings	43.341	35.660	51.241
Physical Activity Level			
Physically Active	25.077	27.603	22.479
Moderately Active	26.678	26.156	27.216
Inactive	48.245	46.241	50.306
Lifestyle Confounders			
Type of Drinker			
Regular Drinker	66.742	74.753	58.501
Occasionally Drinker	15.322	10.615	20.163
Non Drinker	17.937	14.632	21.336
Smoking Status			
Daily Smoker	17.372	19.112	15.582
Occasional Smoker	3.927	4.594	3.241
Former Smoker	44.026	46.807	41.165
Never Smoker	34.675	29.487	40.012

5.1.2 Cross-Tabulations

Cross-tabulations between the chronic disease prevalence and both measures of the food environment are presented in **Table 5.3** and **Table 5.4**.

On average, individuals with type II diabetes lived in areas with a greater average number of supermarkets and large grocery stores (mean: 0.73 vs 0.69), intermediate grocery stores (mean: 2.29 vs 2.14), small grocery stores and convenience stores (mean: 4.40 vs 4.03), and fast-food restaurants (mean: 7.84 vs 7.50) per 10000 individuals, and lower number of local and non-chain restaurants (mean: 13.67 vs 13.41) when assessed using the population-based density measures. The average number of full-service restaurants (mean: 1.25 vs 1.24) per 10000 individuals were similar between individuals with and without type II diabetes. In the area-based measures, individuals with type II diabetes typically resided in areas with lower availability of local and non-chain restaurants (mean: 3.22 vs 2.77). However, individuals with and without type II diabetes, on average, resided in areas with similar numbers of supermarkets and large grocery stores (mean: 0.10 vs 0.09), intermediate grocery stores (mean: 0.41 vs 0.41), small grocery stores and convenience stores (mean: 0.95 vs 0.94), fast-food restaurants (mean: 1.43 s 1.42), and full-service restaurants (mean: 0.23 vs 0.22) per 1000.

Similar differences in the average number of food outlets and cardiovascular disease prevalence were seen as well. Individuals with cardiovascular disease were found to live in areas with a greater number of supermarkets and large grocery stores (mean: 0.79 vs 0.68), intermediate grocery stores (mean: 2.27 vs 2.14), small grocery stores and convenience stores (means: 4.30 vs 3.04), fast-food restaurants (mean: 7.61 vs 7.52), and local and non-chain restaurants (mean: 13.74 vs 13.64) per 10000 individuals, and a decreased availability of full-service restaurants (mean: 13.67 vs 13.41) per 10000 individuals using the population based density measures. However, measured using the area based densities, individuals with cardiovascular disease, on average, resided in areas with a lower average number of intermediate grocery stores (mean: 0.42 vs 0.38), small grocery stores and convenience stores (mean: 0.95 vs 0.87), fast-food restaurants (mean:

1.44 vs 1.30), full-service restaurants (mean: 0.23 vs 0.21), and local and non-chain restaurants (mean: 3.20 vs 2.81) per km^2. No difference in the average number of supermarkets and large grocery stores between individuals with and without cardiovascular disease was observed.

Individuals with hypertension were also found to reside in areas with greater average number of supermarkets and large grocery stores (mean: 0.73 vs 0.68), intermediate grocery stores (mean: 2.20 vs 2.13), and small grocery stores and convenience stores (mean: 4.14 vs 4.03) per 10000 individuals, and lower average number of fast-food restaurants (mean: 7.53 vs 7.50) and local and non-chain restaurants (mean: 13.68 vs 13.49) per 10000 individuals when assessed through population based density measures. Area based food environment measures found similar results. Individuals with hypertension, on average, were found to live in areas with a lower average number of intermediate grocery stores (mean: 0.42 vs 0.37), small grocery stores and convenience stores (mean: 0.98 vs 0.86), fast-food restaurants (mean: 1.47 vs 1.28), full-service restaurants (mean: 0.24 vs 0.21), and local and non-chain restaurants (mean: 3.25 vs 2.93) per km^2. No differences in the average number of supermarkets and large grocery stores (mean: 0.095 vs 0.095) and full-service restaurants (mean: 1.25 vs 1.24) between individuals with and without hypertension was observed.

The results of the cross tabulation stratified by gender are presented in Appendix C.

Table 5.3 Cross Tabulations of Population Based (per 10000 Individuals) Food Environment Densities by Chronic Disease Prevalence: Overall

	Mean (SD)					
Disease Status	Supermarkets and Large Grocery Stores	Intermediate Grocery Stores	Small Grocery and Convenience Stores	Fast-food Restaurants	Full-service Restaurants	Local and Non-chain Restaurants
Type II Diabetes Prevalence						
No Diabetes	0.685 (0.614)	2.137 (1.663)	4.025 (2.906)	7.499 (5.023)	1.244 (1.377)	13.668 (12.405)

Diabetes	0.729 (0.599)	2.294 (1.783)	4.402 (2.981)	7.842 (4.888)	1.245 (1.364)	13.406 (11.197)
Cardiovascular Disease Prevalence						
No Cardiovascular disease	0.684 (0.611)	2.142 (1.670)	4.038 (2.910)	7.519 (5.028)	1.246 (1.381)	13.642 (12.378)
Cardiovascular disease	0.768 (0.646)	2.267 (1.723)	4.300 (2.957)	7.613 (4.792)	1.211 (1.328)	13.735 (11.114)
Hypertension Prevalence						
No Hypertension	0.677 (0.609)	2.134 (1.670)	4.028 (2.930)	7.530 (5.058)	1.243 (1.371)	13.677 (12.459)
Hypertension	0.728 (0.627)	2.201 (1.683)	4.136 (2.847)	7.501 (4.853)	1.245 (1.401)	13.490 (11.681)

Table 5.4 Cross Tabulations of Area Based (per km^2) Food Environment Densities by Chronic Disease Prevalence: Overall

	Mean (SD)					
Disease Status	Supermarkets and Large Grocery Stores	Intermediate Grocery Stores	Small Grocery and Convenience Stores	Fast-food Restaurants	Full-service Restaurants	Local and Non-chain Restaurants
Type II Diabetes Prevalence						
No Diabetes	0.094 (0.141)	0.414 (0.726)	0.950 (1.774)	1.430 (2.175)	0.232 (0.437)	3.217 (7.307)
Diabetes	0.099 (0.140)	0.412 (0.664)	0.936 (1.556)	1.421 (1.956)	0.223 (0.443)	2.769 (5.892)
Cardiovascular Disease Prevalence						
No Cardiovascular disease	0.095 (0.141)	0.416 (0.722)	0.952 (1.765)	1.436 (2.160)	0.232 (0.437)	3.203 (7.242)
Cardiovascular disease	0.095 (0.140)	0.376 (0.696)	0.865 (1.604)	1.297 (2.141)	0.209 (0.436)	2.815 (6.600)
Hypertension Prevalence						
No Hypertension	0.096 (0.143)	0.424 (0.739)	0.976 (1.807)	1.469 (2.219)	0.237 (0.456)	3.248 (7.094)
Hypertension	0.096 (0.143)	0.373 (0.641)	0.856 (1.559)	1.282 (1.917)	0.208 (0.360)	2.929 (7.570)

5.2 Multivariate Analysis

5.2.1 Type II Diabetes

The results of the associations between type II diabetes prevalence and the population-based food environment measures are presented in Table 5.5**.** In the unadjusted model (Model 1), intermediate grocery store (RP: 1.057; 95% CI: 1.013 - 1.103), small grocery store and convenience store (RP: 1.040; 95% CI: 1.020 - 1.061), and fast-food restaurant (RP: 1.023; 95% CI: 1.009 - 1.038) densities were all positively associated with diabetes prevalence, while local and non-chain restaurant availability was inversely associated with the prevalence of diabetes (RP: 0.985; 95% CI: 0.977 - 0.992). After adjusting for socioeconomic confounders, demographic confounders, and neighbourhood level covariates (Model 2), the magnitude of RP of the small grocery stores and convenience stores (RP: 1.031; 95% CI: 1.004 - 1.058), fast-food restaurants (RP: 1.024; 95% CI: 1.008 - 1.039), and local and non-chain restaurants (RP: 0.985; 95% CI: 0.977 - 0.994) densities measures were attenuated but statistically significant. The magnitude and significance of the availability of intermediate grocery stores variable, however, was attenuated to the point of statistical non-significance. In the fully adjusted model (Model 3), which adjusted for potential mediators and lifestyle variables, fast-food restaurant density was positively associated with diabetes prevalence, with the relative prevalence of an individual having type II diabetes increasing by 1.9% for each additional fast-food restaurant (per 10000 population) (RP: 1.019; 95% CI: 1.004 - 1.034). Local and non-chain restaurants density was inversely associated with diabetes prevalence, with the relative prevalence of type II diabetes reduced by 1.3% for each additional restaurant per 10000 population (RP: 0.987; 95% CI: 0.979 - 0.996). Small grocery stores and convenience stores were found to be not associated with diabetes prevalence in Model 3, with the magnitude of the association being attenuated. No associations were seen with the availability of both the supermarkets and large grocery stores and full-service restaurants density measures in any of the assessed models.

Similar findings were seen in the area based food environment measures, reported in Table 5.6. In the fully adjusted model (Model 3), only the availability of fast-food restaurants and local and non-chain restaurants were significantly associated with diabetes prevalence. Each additional fast-food restaurant per km^2 was associated with an 8.6% increase in the relative prevalence of type II diabetes (RP: 1.086; 95% CI: 1.022 - 1.155), while each additional local and non-chain restaurants per km^2 was associated with a 3.1% decrease in type II diabetes prevalence (RP: 1.086; 95% CI: 0.940 - 0.999).

Separate analyses for each sex by both food environment measures are presented in Appendix C. In the fully adjusted model (Model 3) for population based density measures, males were found to be not associated with any measure of the food environment. Females, however, were significantly associated with fast-food restaurants (RP: 1.030; 95% CI: 1.009 - 1.051) and local and non-chain restaurants density (RP: 0.979; 95% CI: 0.968 - 0.990). When densities were calculated using total FSA area, the availability of the fast-food restaurants was found to be positively associated with diabetes prevalence in the male population (RP: 1.089; 95% CI: 1.004 - 1.181), with no statistically significant associations being seen in the female population.

While the objective of this study was to assess the association between chronic disease prevalence and the food environment, meaningful relationships can still be derived with regards to potential confounders and covariates and type II diabetes prevalence. The majority of covariates followed trends outlined in the conceptual framework, with similar associations being seen in both population and area based density measures. Age was found to be a significant predictor of diabetes prevalence, with this association having a significant quadratic trend. Prevalence of diabetes was also found to be significantly lower in females than males, with females seeing a 40% reduction in the relative prevalence of type II diabetes prevalence compared to their male counterparts. Increasing income quintiles, marriage, and regular drinking were all associated with reduced diabetes prevalence, whereas the length of residency, neighbourhood percentage of high school education, and neighbourhood percentage of visual minority were all associated with increased diabetes prevalence. Smoking status, education level, population density, neighbourhood percentage of low income individuals, and percentage of individuals driving to work were not significantly associated with diabetes prevalence. In terms of potential mediators, increasing weight class was found to be significantly associated with diabetes, with both overweight and obese individual having greater prevalence of type II diabetes compared to underweight and normal weight individuals. Increasing physical activity levels, however, were negatively associated with diabetes, while fruits & vegetables consumption was not found to be a significant predictor.

Table 5.5 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Type II Diabetes Prevalence and Population based (per 10000 individual) Food Environment Measures: Overall

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.051	1.013	1.020
	(0.970 - 1.139)	(0.927 - 1.108)	(0.933 - 1.116)
Intermediate Grocery Stores	1.057**	1.034	1.035
	(1.013 - 1.103)	(0.986 - 1.083)	(0.990 - 1.083)
Small Grocery and Convenience Stores	1.040***	1.031**	1.020
	(1.020 - 1.061)	(1.004 - 1.058)	(0.996 - 1.045)
Fast-food Restaurants	1.023***	1.024***	1.019**
	(1.009 - 1.038)	(1.008 - 1.039)	(1.004 - 1.034)
Full-service Restaurants	0.980	0.997	1.010
	(0.934 - 1.027)	(0.948 - 1.049)	(0.961 - 1.061)
Local and Non-chain Restaurants	0.985***	0.985***	0.987***
	(0.977 - 0.992)	(0.977 - 0.994)	(0.979 - 0.996)
Individual Level Confounders			
Age			
Age	--	1.323***	1.286***
		(1.243 - 1.408)	(1.210 - 1.367)
Age^2	--	0.998***	0.998***
		(0.998 - 0.999)	(0.998 - 0.999)
Gender			
Female	--	0.649***	0.594***
		(0.580 - 0.725)	(0.529 - 0.666)
Male (ref)	--		
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.682***	1.632***
		(1.213 - 2.331)	(1.198 - 2.222)
Length of Residency: +10 years	--	1.225***	1.258***
		(1.065 - 1.410)	(1.096 - 1.444)
Canadian born (ref)	--		
Marital Status			

Married	--	0.790** (0.643 - 0.971)	0.803** (0.668 - 0.967)
Widowed/Separated/ Divorced	--	0.740*** (0.596 - 0.918)	0.781** (0.643 - 0.948)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.770*** (0.672 - 0.882)	0.895 (0.778 - 1.030)
Incomplete Postsecondary Education	--	0.918 (0.741 - 1.136)	1.037 (0.836 - 1.286)
High School Diploma	--	0.929 (0.780 - 1.106)	1.019 (0.861 - 1.206)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.605*** (0.496 - 0.740)	0.752*** (0.612 - 0.925)
Quintile 4	--	0.670*** (0.567 - 0.791)	0.777*** (0.653 - 0.925)
Quintile 3	--	0.728*** (0.617 - 0.858)	0.819** (0.692 - 0.969)
Quintile 2	--	0.780*** (0.666 - 0.914)	0.842** (0.722 - 0.983)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.007*** (1.003 - 1.010)	1.006*** (1.003 - 1.010)
Percentage of Low Income	--	1.005 (0.993 - 1.018)	1.008 (0.996 - 1.020)
Percentage of High School Education	--	1.013*** (1.006 - 1.021)	1.007** (1.000 - 1.014)
Percentage of Driving to Work	--	1.004 (0.996 - 1.013)	1.004 (0.996 - 1.012)
Population Density	--	1.000 (1.000 - 1.000)	1.000 (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	3.810*** (3.190 - 4.552)
Overweight	--	--	1.648*** (1.366 - 1.988)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			

5 or More Daily Servings			0.926 (0.825 - 1.039)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.710*** (0.606 - 0.831)
Moderately Active	--	--	0.877** (0.770 - 0.999)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.568*** (0.496 - 0.652)
Occasionally Drinker	--	--	0.922 (0.797 - 1.067)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	0.949 (0.796 - 1.131)
Occasional Smoker	--	--	0.789 (0.529 - 1.178)
Former Smoker	--	--	0.986 (0.865 - 1.123)
Never Smoker (ref)	--	--	--

Table 5.6 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Type II Diabetes Prevalence and Area based (per km^2) Food Environment Measures: Overall

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.707* (0.995 - 2.929)	1.515 (0.762 - 3.013)	1.608 (0.796 - 3.247)
Intermediate Grocery Stores	1.139 (0.964 - 1.346)	1.089 (0.902 - 1.315)	1.131 (0.934 - 1.371)
Small Grocery and Convenience Stores	0.984 (0.928 - 1.044)	1.033 (0.955 - 1.117)	1.004 (0.931 - 1.083)
Fast-food Restaurants	1.051 (0.985 - 1.121)	1.086*** (1.020 - 1.157)	1.086*** (1.022 - 1.155)
Full-service Restaurants	0.939 (0.736 - 1.200)	0.957 (0.734 - 1.247)	0.971 (0.749 - 1.258)
Local and Non-chain Restaurants	0.962**	0.969*	0.969**

	(0.931 - 0.995)	(0.939 - 1.001)	(0.940 - 0.999)
Individual Level Confounders			
Age			
Age	--	1.331*** (1.249 - 1.417)	1.295*** (1.217 - 1.379)
Age^2	--	0.998*** (0.998 - 0.999)	0.998*** (0.998 - 0.999)
Gender			
Female	--	0.656*** (0.587 - 0.733)	0.598*** (0.533 - 0.671)
Male (ref)	--		
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.674*** (1.201 - 2.332)	1.639*** (1.201 - 2.236)
Length of Residency: +10 years	--	1.230*** (1.070 - 1.414)	1.257*** (1.097 - 1.440)
Canadian born (ref)	--		
Marital Status			
Married	--	0.796** (0.648 - 0.979)	0.810** (0.674 - 0.973)
Widowed/Separated/ Divorced	--	0.751*** (0.604 - 0.933)	0.793** (0.653 - 0.964)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.769*** (0.671 - 0.881)	0.894 (0.777 - 1.027)
Incomplete Postsecondary Education	--	0.909 (0.733 - 1.127)	1.027 (0.826 - 1.276)
High School Diploma	--	0.927 (0.778 - 1.103)	1.016 (0.859 - 1.202)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.602*** (0.492 - 0.735)	0.748*** (0.608 - 0.920)
Quintile 4	--	0.662*** (0.560 - 0.782)	0.769*** (0.646 - 0.916)
Quintile 3	--	0.731*** (0.620 - 0.861)	0.822** (0.695 - 0.972)
Quintile 2	--	0.765*** (0.653 - 0.896)	0.825** (0.707 - 0.962)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.006*** (1.003 - 1.010)	1.006*** (1.002 - 1.009)

Percentage of Low Income	--	1.005 (0.993 - 1.017)	1.006 (0.994 - 1.018)
Percentage of High School Education	--	1.017*** (1.010 - 1.024)	1.010*** (1.003 - 1.017)
Percentage of Driving to Work	--	1.005 (0.996 - 1.013)	1.005 (0.996 - 1.013)
Population Density	--	1.000** (1.000 - 1.000)	1.000* (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	3.831*** (3.208 - 4.575)
Overweight	--	--	1.618*** (1.343 - 1.949)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			0.946 (0.844 - 1.061)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.704*** (0.602 - 0.823)
Moderately Active	--	--	0.873** (0.766 - 0.996)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.567*** (0.494 - 0.649)
Occasionally Drinker	--	--	0.916 (0.792 - 1.059)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	0.942 (0.791 - 1.123)
Occasional Smoker	--	--	0.791 (0.531 - 1.181)
Former Smoker	--	--	0.981 (0.863 - 1.115)
Never Smoker (ref)	--	--	--

5.2.2 Cardiovascular Disease

The main results for the association between cardiovascular disease prevalence and the population-based food environment measures are presented in Table 5.7. Within the unadjusted model (Model 1), the density of supermarkets and large grocery stores (RP: 1.180; 95% CI: 1.079 - 1.291) and small grocery stores and convenience stores (RP: 1.029; 95% CI: 1.008 - 1.051) were both found to be positively associated with cardiovascular disease. However, these associations were attenuated and found to be non-significant after adjusting for socioeconomic confounders, demographic confounders, and neighbourhood level covariates (Model 2) and for potential mediators and lifestyle variables (Model 3). No associations were seen with the availability of intermediate grocery stores, fast-food restaurants, full-service restaurants, and local and non-chain restaurants density measures in any of the relevant models.

Similar results were observed with the area-based density measures, shown in Table 5.8. No statistically significant associations were observed between the prevalence of cardiovascular disease and availability of the food outlet measures, with the densities of supermarkets and large grocery stores, small grocery stores and convenience stores, intermediate grocery stores, fast-food restaurants, full-service restaurants, and local and non-chain restaurants density measures being statistically non-significant in all 3 models.

Null associations persisted after stratifying for sex. When the food environment was assessed as population based densities, cardiovascular disease was positively associated with supermarket and large grocery store density and small grocery and convenience store density in both the male and female populations, while intermediate grocery store availability was positively associated with cardiovascular disease in the female population. However, after adjusting for confounders and covariates, these association were attenuated, such that all measures of the food environment were no longer statistically associated with cardiovascular disease in the fully adjusted model (Model 3) for both sexes ($p>0.10$). In the area based food environment measures, however, cardiovascular disease prevalence was found to be inversely associated with the availability of intermediate grocery stores in the male population (RP: 0.671; 95% CI: 0.476 - 0.946). In the fully adjusted model (Model 3), an additional intermediate grocery store per km^2 within each FSA was associated with a 32.9% reduction in cardiovascular disease prevalence. All other food store measures were statistically non-significant with cardiovascular disease in both sexes. Separate analyses by sex for both food environment measures can be found in Appendix C.

The association between cardiovascular disease prevalence and the covariates and confounders, outlined in the conceptual framework were in the expected direction. Advancing age was found to be a significantly associated with cardiovascular disease and followed a quadratic trend. Females were found to have a lower prevalence of cardiovascular disease as well, with females having a 44.8% reduction in the relative prevalence of self-reporting cardiovascular disease compared to males. Increasing income quintiles and regular drinking were both found to be inversely associated with cardiovascular disease prevalence, while smoking status was associated with increased prevalence of cardiovascular disease. Education level, length of residency, population density, marital status, and neighbourhood percentage of low income individuals, high school education, visible minorities and individuals driving to work were all found to be not statistically associated with cardiovascular disease prevalence. The associations between cardiovascular disease and the potential mediators were similar to type II diabetes, with increasing weight class being positively associated, increasing physical activity levels being negatively associated, and fruits & vegetables consumption not being associated with cardiovascular disease prevalence.

Table 5.7 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Cardiovascular Disease Prevalence and Population based (per 10000 individual) Food Environment Measures: Overall

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.180*** (1.079 - 1.291)	1.076 (0.972 - 1.192)	1.079 (0.973 - 1.198)
Intermediate Grocery Stores	1.015 (0.972 - 1.059)	0.979 (0.933 - 1.026)	0.983 (0.938 - 1.030)

Small Grocery and Convenience Stores	1.029***	1.02	1.015
	(1.008 - 1.051)	(0.993 - 1.049)	(0.987 - 1.044)
Fast-food Restaurants	1.009	1.002	0.999
	(0.991 - 1.027)	(0.983 - 1.021)	(0.980 - 1.018)
Full-service Restaurants	0.96	0.976	0.976
	(0.911 - 1.013)	(0.922 - 1.033)	(0.921 - 1.034)
Local and Non-chain Restaurants	0.994	0.997	0.999
	(0.986 - 1.001)	(0.989 - 1.005)	(0.990 - 1.007)
Individual Level Confounders			
Age			
Age	--	1.281***	1.249***
		(1.186 - 1.385)	(1.155 - 1.351)
Age^2	--	0.999***	0.999***
		(0.998 - 0.999)	(0.998 - 0.999)
Gender			
Female	--	0.537***	0.553***
		(0.477 - 0.605)	(0.490 - 0.625)
Male (ref)	--		
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	0.697	0.758
		(0.405 - 1.200)	(0.443 - 1.295)
Length of Residency: +10 years	--	0.795**	0.836
		(0.644 - 0.982)	(0.670 - 1.043)
Canadian born (ref)	--		
Marital Status			
Married	--	1.164	1.167
		(0.943 - 1.437)	(0.940 - 1.449)
Widowed/Separated/ Divorced	--	1.201*	1.188
		(0.969 - 1.488)	(0.956 - 1.475)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.814*	0.895
		(0.663 - 1.000)	(0.731 - 1.095)
Incomplete Postsecondary Education	--	0.826	0.876
		(0.639 - 1.069)	(0.678 - 1.132)
High School Diploma	--	0.792**	0.832
		(0.628 - 0.999)	(0.658 - 1.053)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.622***	0.704***
		(0.498 - 0.775)	(0.560 - 0.885)
Quintile 4	--	0.634***	0.702***
		(0.515 - 0.780)	(0.568 - 0.868)

Quintile 3	--	0.788*** (0.659 - 0.942)	0.824** (0.686 - 0.989)
Quintile 2	--	0.86 (0.703 - 1.053)	0.906 (0.737 - 1.115)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.001 (0.996 - 1.005)	1.001 (0.997 - 1.006)
Percentage of Low Income	--	1.002 (0.987 - 1.016)	1.001 (0.987 - 1.015)
Percentage of High School Education	--	1.005 (0.998 - 1.013)	1.002 (0.995 - 1.010)
Percentage of Driving to Work	--	0.996 (0.987 - 1.004)	0.995 (0.987 - 1.003)
Population Density	--	1.000* (1.000 - 1.000)	1.000* (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	1.664*** (1.414 - 1.957)
Overweight	--	--	1.312*** (1.108 - 1.555)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			1.009 (0.893 - 1.141)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.775*** (0.658 - 0.913)
Moderately Active	--	--	0.874* (0.752 - 1.016)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.780*** (0.666 - 0.915)
Occasionally Drinker	--	--	1.039 (0.878 - 1.229)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	1.554*** (1.236 - 1.954)
Occasional Smoker	--	--	1.279 (0.936 - 1.748)

Former Smoker	--	--	1.413*** (1.208 - 1.653)
Never Smoker (ref)	--	--	--

Table 5.8 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Cardiovascular Disease Prevalence and Area based (per km^2) Food Environment Measures: Overall

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.485 (0.549 - 4.014)	1.407 (0.480 - 4.126)	1.488 (0.507 - 4.367)
Intermediate Grocery Stores	0.9 (0.734 - 1.103)	0.819 (0.626 - 1.071)	0.859 (0.655 - 1.128)
Small Grocery and Convenience Stores	1.047 (0.972 - 1.128)	1.044 (0.949 - 1.147)	1.025 (0.930 - 1.129)
Fast-food Restaurants	0.946 (0.865 - 1.034)	0.962 (0.874 - 1.060)	0.959 (0.870 - 1.056)
Full-service Restaurants	0.986 (0.754 - 1.289)	1.037 (0.788 - 1.363)	1.002 (0.755 - 1.331)
Local and Non-chain Restaurants	0.997 (0.969 - 1.025)	1.001 (0.970 - 1.033)	1.002 (0.971 - 1.034)
Individual Level Confounders			
Age			
Age	--	1.290*** (1.193 - 1.395)	1.257*** (1.162 - 1.359)
Age^2	--	0.999*** (0.998 - 0.999)	0.999*** (0.998 - 0.999)
Gender			
Female	--	0.536*** (0.476 - 0.604)	0.552*** (0.488 - 0.623)
Male (ref)	--		
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	0.706 (0.411 - 1.214)	0.765 (0.448 - 1.306)
Length of Residency: +10 years	--	0.781** (0.634 - 0.962)	0.822* (0.661 - 1.023)
Canadian born (ref)	--		
Marital Status			
Married	--	1.156 (0.938 - 1.425)	1.154 (0.932 - 1.430)

Widowed/Separated/ Divorced	--	1.185 (0.956 - 1.468)	1.167 (0.940 - 1.450)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.822* (0.674 - 1.004)	0.904 (0.742 - 1.100)
Incomplete Postsecondary Education	--	0.838 (0.651 - 1.077)	0.888 (0.691 - 1.141)
High School Diploma	--	0.807* (0.642 - 1.014)	0.847 (0.671 - 1.069)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.613*** (0.491 - 0.765)	0.697*** (0.554 - 0.877)
Quintile 4	--	0.628*** (0.509 - 0.773)	0.699*** (0.565 - 0.865)
Quintile 3	--	0.779*** (0.652 - 0.931)	0.819** (0.682 - 0.982)
Quintile 2	--	0.848 (0.692 - 1.039)	0.897 (0.729 - 1.103)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1 (0.995 - 1.004)	1 (0.996 - 1.005)
Percentage of Low Income	--	1.005 (0.992 - 1.019)	1.005 (0.992 - 1.018)
Percentage of High School Education	--	1.007** (1.000 - 1.014)	1.004 (0.996 - 1.011)
Percentage of Driving to Work	--	0.996 (0.987 - 1.004)	0.995 (0.987 - 1.004)
Population Density	--	1 (1.000 - 1.000)	1 (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	1.660*** (1.412 - 1.952)
Overweight	--	--	1.301*** (1.100 - 1.540)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			1.01 (0.894 - 1.142)

Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.776*** (0.660 - 0.913)
Moderately Active	--	--	0.883 (0.760 - 1.026)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.768*** (0.657 - 0.897)
Occasionally Drinker	--	--	1.024 (0.867 - 1.211)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	1.561*** (1.246 - 1.955)
Occasional Smoker	--	--	1.278 (0.933 - 1.751)
Former Smoker	--	--	1.409*** (1.204 - 1.649)
Never Smoker (ref)	--	--	--

5.2.3 Hypertension

The results of the association between hypertension and food environment measures are reported in Table 5.9. In the unadjusted model (Model 1), the density of supermarkets and large grocery stores (RP: 1.077; 95% CI: 1.030 - 1.126) and small grocery stores and convenience stores (RP: 1.013; 95% CI: 1.001 - 1.025) were positively associated with hypertension prevalence, while the availability of local and non-chain restaurants was negatively associated with hypertension rates (RP: 0.994; 95% CI: 0.990 - 0.997). However, these associations were attenuated and were not statistically significant after adjusting for socioeconomic confounders, demographic confounders, and neighbourhood level covariates (Model 2) and for potential mediators and lifestyle variables (Model 3). No associations were seen with the availability of fast-food restaurants and full-service restaurants in any of the models.

The area based density measures, presented in Table 5.10, found similar results with one exception. Fast-food restaurant density was inversely associated with hypertension prevalence after adjusting for confounders and covariates in Model 2 (RP: 0.954; 95% CI: 0.915 - 0.995), and after adjusting for potential mediators and lifestyle variables in Model 3 (RP: 0.952; 95% CI: 0.913 - 0.993). In the fully adjusted model, an additional fast-food restaurant per km^2 within each FSA was associated with a 4.8% reduction in hypertension prevalence. No statistically significant associations were observed between the other food environment measures and hypertension in any of the 3 models.

No statistically significant associations were found between the food environment and hypertension in both sexes. When the food environment was assessed as population-based densities, hypertension was positively associated with supermarket and large grocery store density in the male population in Model 1 (RP: 1.106; 95% CI: 1.036 - 1.181). However, after adjusting for confounders and covariates, these associations were attenuated, with supermarket density no longer being statistically significant in fully adjusted model (Model 3). No other food environment measures were statistically significant in the male population ($p>0.10$). In the female population, intermediate grocery stores (RP: 1.032; 95% CI: 1.006 - 1.059), small grocery and convenience stores (RP: 1.022; 95% CI: 1.005 - 1.040), and local and non-chain restaurants (RP: 0.991; 95% CI: 0.986 - 0.996) were all associated with hypertension in the unadjusted model (Model 1). However, after adjusting for the effects of possible confounders and covariates (Model 3), these associations were attenuated and no longer statistically significant. Stratification by sex in the area-based food environment measures initially found no associations, with the majority of the food outlets being not significantly associated with hypertension prevalence in the unadjusted models (Model 1). However, after adjusting for the possible confounders, covariates, and potential mediators (Model 2 and Model 3), certain food outlets measures were found to be significantly associated with hypertension in both sexes. In the male population, the availability of local and non-chain restaurants density became significantly associated with hypertension in the fully adjusted model, with each additional local or non-chain restaurant per km^2 at the FSA level was associated with a 2.4% increase in the prevalence of hypertension (RP: 1.024; 95% CI: 1.006 - 1.042). Intermediate grocery stores became significantly associated with hypertension in the males population after adjusting for potential confounders and covariates (Model 2) (RP: 0.816; 95% CI: 0.696 - 0.956), however this association was attenuated and became statistically non-significant after adjusting for potential mediators and lifestyle variables (Model 3). In the female sample, fast-food restaurant and full-service restaurant availability were both associated with hypertension. Each additional fast food restaurant per km^2 associated with a 6.4% decrease in the prevalence of hypertension (RP: 0.936; 95% CI: 0.884 - 0.991), while the relative prevalence of hypertension increased by 24% for every additional full-service restaurant per km^2 at the FSA level (RP: 1.240; 95% CI: 1.002 - 1.535). Separate analyses by sex for both food environment measures can be found in Appendix C.

The association between hypertension and the covariates and confounders outlined in the conceptual framework were similar to the trends seen in the literature. Age was found to be a significant predictor of hypertension, with prevalence of the condition following a quadratic trend. Females were found to have a lower prevalence of hypertension, with females having 6.2% lower hypertension prevalence compared to their male counterparts. Increasing education level and income quintiles were both found to be inversely associated with hypertension prevalence, while neighbourhood percentage of visible minority and neighbourhood percentage of number of individuals driving to work were positively associated with hypertension. Length of residency, marital status, population density, regular drinking, smoking status, neighbourhood percentage of low income individuals, and neighbourhood percentage of high school education, were all found to be statistically non-significant predictor of hypertension prevalence. The association between the potential mediators and hypertension were similar to the other chronic conditions. Increasing weight class was positively associated with hypertension prevalence, with obese individuals being at greater risk of having the disease compared to their overweight counterparts. Increasing physical activity levels were negatively associated with hypertension prevalence, however a significant reduction in prevalence was only seen in individuals who were physically active rather than individuals who engaged in moderately active. Fruits & vegetables consumption was not associated with hypertension prevalence.

Table 5.9 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Hypertension Prevalence and Population based (per 10000 individual) Food Environment Measures: Overall

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.077***	1.019	1.027
	(1.030 - 1.126)	(0.970 - 1.069)	(0.978 - 1.079)
Intermediate Grocery Stores	1.017*	0.998	1
	(0.998 - 1.037)	(0.977 - 1.018)	(0.981 - 1.020)
Small Grocery and Convenience Stores	1.013**	1.012*	1.009
	(1.001 - 1.025)	(0.998 - 1.027)	(0.995 - 1.023)
Fast-food Restaurants	1	0.995	0.993
	(0.991 - 1.009)	(0.987 - 1.004)	(0.985 - 1.002)
Full-service Restaurants	1.009	1.012	1.017
	(0.980 - 1.038)	(0.982 - 1.042)	(0.987 - 1.047)
Local and Non-chain Restaurants	0.994***	0.999	1
	(0.990 - 0.997)	(0.995 - 1.003)	(0.996 - 1.004)
Individual Level Confounders			
Age			
Age	--	1.209***	1.180***
		(1.167 - 1.253)	(1.139 - 1.223)
Age^2	--	0.999***	0.999***
		(0.999 - 0.999)	(0.999 - 0.999)
Gender			
Female	--	0.905***	0.938**
		(0.851 - 0.961)	(0.881 - 0.998)
Male (ref)	--		
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.139	1.192
		(0.897 - 1.447)	(0.941 - 1.510)
Length of Residency: +10 years	--	1.012	1.032
		(0.929 - 1.102)	(0.947 - 1.126)
Canadian born (ref)	--		
Marital Status			
Married	--	0.944	0.939
		(0.849 - 1.049)	(0.849 - 1.038)
Widowed/Separated/ Divorced	--	0.945	0.957
		(0.844 - 1.058)	(0.859 - 1.066)
Single (ref)	--	--	--
Education Level			

Completed Postsecondary Education	--	0.810*** (0.742 - 0.885)	0.885*** (0.810 - 0.968)
Incomplete Postsecondary Education	--	0.915 (0.806 - 1.039)	0.951 (0.838 - 1.080)
High School Diploma	--	0.887** (0.801 - 0.982)	0.929 (0.839 - 1.029)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.838*** (0.750 - 0.937)	0.899* (0.801 - 1.008)
Quintile 4	--	0.837*** (0.756 - 0.927)	0.875** (0.788 - 0.973)
Quintile 3	--	0.825*** (0.749 - 0.909)	0.839*** (0.760 - 0.926)
Quintile 2	--	0.919* (0.840 - 1.005)	0.951 (0.868 - 1.041)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.003** (1.001 - 1.005)	1.003*** (1.001 - 1.005)
Percentage of Low Income	--	0.995 (0.989 - 1.002)	0.997 (0.991 - 1.004)
Percentage of High School Education	--	1.007*** (1.003 - 1.012)	1.003 (0.999 - 1.008)
Percentage of Driving to Work	--	1.004* (1.000 - 1.009)	1.005** (1.000 - 1.009)
Population Density	--	1 (1.000 - 1.000)	1 (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	2.590*** (2.367 - 2.834)
Overweight	--	--	1.597*** (1.456 - 1.752)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			0.949 (0.890 - 1.012)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.789*** (0.728 - 0.855)

Moderately Active	--	--	0.961 (0.895 - 1.032)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.930* (0.859 - 1.006)
Occasionally Drinker	--	--	0.977 (0.891 - 1.072)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	0.986 (0.886 - 1.097)
Occasional Smoker	--	--	0.846* (0.715 - 1.002)
Former Smoker	--	--	0.932* (0.867 - 1.002)
Never Smoker (ref)	--	--	--

Table 5.10 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Hypertension Prevalence and Area based (per km^2) Food Environment Measures: Overall

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.218 (0.883 - 1.679)	1.106 (0.783 - 1.563)	1.171 (0.825 - 1.661)
Intermediate Grocery Stores	0.988 (0.901 - 1.084)	0.939 (0.845 - 1.045)	0.973 (0.875 - 1.082)
Small Grocery and Convenience Stores	1.016 (0.977 - 1.057)	1.024 (0.977 - 1.074)	1.013 (0.967 - 1.062)
Fast-food Restaurants	0.962* (0.921 - 1.005)	0.954** (0.915 - 0.995)	0.952** (0.913 - 0.993)
Full-service Restaurants	1.094 (0.937 - 1.276)	1.094 (0.942 - 1.270)	1.119 (0.964 - 1.299)
Local and Non-chain Restaurants	0.989 (0.975 - 1.003)	1.007 (0.993 - 1.021)	1.007 (0.994 - 1.021)
Individual Level Confounders			
Age			
Age	--	1.208*** (1.166 - 1.252)	1.180*** (1.139 - 1.222)
Age^2	--	0.999***	0.999***

		(0.999 - 0.999)	(0.999 - 0.999)
Gender			
Female	--	0.903***	0.938**
		(0.850 - 0.960)	(0.882 - 0.998)
Male (ref)	--		
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.116	1.167
		(0.876 - 1.421)	(0.919 - 1.483)
Length of Residency: +10 years	--	1.014	1.036
		(0.932 - 1.104)	(0.951 - 1.129)
Canadian born (ref)	--		
Marital Status			
Married	--	0.941	0.931
		(0.846 - 1.046)	(0.842 - 1.029)
Widowed/Separated/ Divorced	--	0.939	0.946
		(0.838 - 1.052)	(0.849 - 1.054)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.809***	0.882***
		(0.742 - 0.882)	(0.808 - 0.962)
Incomplete Postsecondary Education	--	0.912	0.945
		(0.804 - 1.035)	(0.833 - 1.072)
High School Diploma	--	0.886**	0.929
		(0.801 - 0.980)	(0.841 - 1.028)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.837***	0.897*
		(0.748 - 0.935)	(0.799 - 1.007)
Quintile 4	--	0.832***	0.869***
		(0.751 - 0.922)	(0.782 - 0.966)
Quintile 3	--	0.823***	0.837***
		(0.746 - 0.907)	(0.759 - 0.924)
Quintile 2	--	0.911**	0.942
		(0.834 - 0.997)	(0.861 - 1.032)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.002**	1.002**
		(1.000 - 1.004)	(1.000 - 1.004)
Percentage of Low Income	--	0.996	0.998
		(0.990 - 1.002)	(0.992 - 1.004)
Percentage of High School Education	--	1.008***	1.004**
		(1.004 - 1.013)	(1.000 - 1.009)
Percentage of Driving to Work	--	1.005*	1.005**

		(1.000 - 1.009)	(1.000 - 1.009)
Population Density	--	1 (1.000 - 1.000)	1 (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	2.605*** (2.381 - 2.851)
Overweight	--	--	1.605*** (1.464 - 1.760)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			0.953 (0.894 - 1.016)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.785*** (0.725 - 0.851)
Moderately Active	--	--	0.961 (0.895 - 1.032)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.935* (0.864 - 1.011)
Occasionally Drinker	--	--	0.982 (0.895 - 1.077)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	0.996 (0.896 - 1.107)
Occasional Smoker	--	--	0.852* (0.720 - 1.009)
Former Smoker	--	--	0.937* (0.871 - 1.007)
Never Smoker (ref)	--	--	--

5.3 Mediation Analysis

A general summary of the results for the Baron and Kenny analysis for the overall and sex-specific results are presented in Tables 4.13-15 (Weight Class), Tables 4.16-18 (Fruits & vegetables Consumption), and Table 4.19-21 (Physical Activity). Full regression tables of the Baron and Kenny analysis are presented in Appendix D, E, and F. In order for mediation to be determined, two conditions were required to be met. The primary requirement was that Steps 1 through 3, outlined in Section 3.7.3.3, must be established to determine the existence of a possible intermediate pathway between the exposure and outcome measures. The second requirement was the confirmation of Step 4, which compared the relative prevalence in the primary modified Poisson regression model (Step 1) to adjusted models that controlled for the effects of mediating variables (Step 3) for any attenuation in effect size. If the relative prevalence was completely attenuated, then complete mediation was present. If no or limited attenuation of effect size was seen, partial mediation was confirmed. If any of these steps are not established, no mediation was established.

5.3.1 Obesity

5.3.1.1 Type II Diabetes

Through the mediation analysis, weight class was found to be a partial mediator between two measures of the food environment and diabetes prevalence. In the Step 1, which assessed if the exposures measures were associated with the prevalence of type II diabetes, only 3 measures were found to be significantly associated: small grocery and convenience store density, fast-food restaurant density, and local and non-chain restaurant density. However, in Step 2, which assessed if the exposure measures were associated with weight class when treated as an outcome, small grocery and convenience store density was found to be unassociated, eliminating the exposure measure from the Baron and Kenny analysis. Step 3 was found to be significant for all measures, with prevalence of being overweight or obese being positively associated with diabetes prevalence after adjusting for the food environment measures. However, when comparing the relative prevalence from the modified Poisson regression model (Step 1) to the adjusted model in Step 3, the relative prevalence of local and non-chain restaurant density was found to increase in effect size, with an attenuation of 0.3% being observed within the adjusted model. A very small attenuation in relative prevalence was seen with fast-food restaurant density, with a 0.1% reduction in prevalence of diabetes being seen after adjusting for weight class. As they were both the only measures to meet all 4 Baron and Kenny mediation requirements, weight class was found to partially mediate the association between both fast-food restaurant density and local and non-chain restaurant density and type II diabetes.

After stratifying the analysis by sex, similar associations were seen in the female population, with weight class mediating the association between both local and non-chain restaurant availability and fast-food restaurant availability with the prevalence of type II diabetes. Steps 1 through 3 were all found to be significant with both measures. A 0.4% reduction in relative prevalence was seen within the fast-food restaurant density while a 0.2% reduction in prevalence was observed within local and non-chain restaurants when comparing the unadjusted (Step 1) and adjusted models (Step 3). Mediation was not observed in the male population.

5.3.1.2 Cardiovascular Disease and Hypertension Prevalence

Weight class was not an intermediary variable on the casual pathway between any measure of the food environment and both cardiovascular disease and hypertension prevalence. No measures of the food environment were found to be significantly associated with cardiovascular disease or hypertension when assessed in Step 1, resulting in all of the food environment measures failing to meet the first criterion outlined in Baron and Kenny mediation analysis. Four of the food environment measures, however, did meet the requirements for Step 2 in both analyses, with the availability of supermarkets and large grocery stores, intermediate grocery stores, fast-food restaurants, and local and non-chain restaurants all being significantly associated with weight class. Furthermore, weight class was found to be positively associated with both cardiovascular disease and hypertension prevalence, meeting the requirements for Step 3. Due to Step 1 not being met in the study population, weight class was found to not mediate the association between neighbourhood food environment and both chronic conditions. Similar associations were seen in both genders separately, with the densities measures of the food environment not being associated with cardiovascular disease or hypertension prevalence in Step 1.

Table 5.13 Summary of Baron Kenny Analysis: Weight Class in the Overall Study Population

Type II Diabetes					
Exposure Measures:	**Baron & Kenny Steps** Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	
Supermarkets and Large Grocery Stores	No	Yes		No	No
Intermediate Grocery Stores	No	Yes		No	No
Small Grocery and Convenience Stores	Yes	No	Yes	No	No
Fast-food Restaurants	Yes	Yes		Yes	**Partial**
Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	Yes	Yes		Yes	**Partial**
Cardiovascular Disease					
Exposure Measures:	**Baron & Kenny Steps** Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated	

				compared to step 1?	
Supermarkets and Large Grocery Stores	No	Yes		No	No
Intermediate Grocery Stores	No	Yes		No	No
Small Grocery and Convenience Stores	No	No	Yes	No	No
Fast-food Restaurants	No	Yes		No	No
Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	No	Yes		No	No
Hypertension					
Exposure Measures:	**Baron & Kenny Steps**				
	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	(No, Partial, Complete)
Supermarkets and Large Grocery Stores	No	Yes		No	No
Intermediate Grocery Stores	No	Yes		No	No
Small Grocery and Convenience Stores	No	No	Yes	No	No

Fast-food Restaurants	No	Yes		No	No
Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	No	Yes		No	No

Table 5.14 Summary of Baron Kenny Analysis: Weight Class in the Male Study Population

Type II Diabetes					
Exposure	**Baron & Kenny Steps**				
Measures:	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	(No, Partial, Complete)
Supermarkets and Large Grocery Stores	No	Yes		No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	No	Yes	No	No
Fast-food Restaurants	No	No		No	No
Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	No	Yes		No	No

Cardiovascular Disease					
Exposure Measures:	**Baron & Kenny Steps**				
	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	
Supermarkets and Large Grocery Stores	No	Yes		No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	No	Yes	No	No
Fast-food Restaurants	No	No		No	No
Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	No	Yes		No	No

Hypertension					
Exposure Measures:	**Baron & Kenny Steps**				
	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	

Supermarkets and Large Grocery Stores	No	Yes		No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	No	Yes	No	No
Fast-food Restaurants	No	No		No	No
Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	No	Yes		No	No

Table 5.15 Summary of Baron Kenny Analysis: Weight Class in the Female Study Population

Type II Diabetes					
Exposure Measures:	**Baron & Kenny Steps**				
	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	(No, Partial, Complete)
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	Yes		No	No
Small Grocery and	No	Yes	Yes	No	No

Convenience Stores	[redacted]			[redacted]	
Fast-food Restaurants	Yes	Yes		Yes	**Partial**
Full-service Restaurants	[redacted]	[redacted]		[redacted]	No
Local and Non-chain Restaurants	Yes	Yes		Yes	**Partial**
Cardiovascular Disease					
Exposure		**Baron & Kenny Steps**			
Measures: The availability of the food environment (per 10000 individuals)	Step 1: Does the exposure predict outcome?	Step 2: Does the exposure predict mediator?	Step 3: Does the mediator predict outcome, after adjusted for exposure?	Step 4: In Step 3, is the association between exposure and outcome attenuated compared to step 1?	Mediator Status (No, Partial, Complete)
Supermarkets and Large Grocery Stores	[redacted]	[redacted]		[redacted]	No
Intermediate Grocery Stores	[redacted]	Yes		[redacted]	No
Small Grocery and Convenience Stores	[redacted]	Yes	Yes	[redacted]	No
Fast-food Restaurants	[redacted]	Yes		[redacted]	No
Full-service Restaurants	[redacted]	[redacted]		[redacted]	No
Local and Non-chain Restaurants	[redacted]	Yes		[redacted]	No
Hypertension					
		Baron & Kenny Steps			

Exposure Measures: The availability of the food environment (per 10000 individuals)	Step 1: Does the exposure predict outcome?	Step 2: Does the exposure predict mediator?	Step 3: Does the mediator predict outcome, after adjusted for exposure?	Step 4: In Step 3, is the association between exposure and outcome attenuated compared to step 1?	Mediator Status (No, Partial, Complete)
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	Yes		No	No
Small Grocery and Convenience Stores	No	Yes	Yes	No	No
Fast-food Restaurants	No	Yes		No	No
Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	No	Yes		No	No

5.3.2 Fruit & vegetable Consumption

5.3.2.1 Type II Diabetes

Fruit & vegetable consumption was found to be a partial mediator between a single measure of the food environment and type II diabetes prevalence. In the primary step (Step 1), which assessed whether the exposure measures predicted diabetes prevalence, only 3 measures were found to be significantly associated with diabetes: small grocery and convenience store density, fast-food restaurant density, and local and non-chain restaurant density. However, in step 2, which assessed if the exposure measures predicted fruits & vegetables dietary patterns, small grocery and convenience store density and local and non-chain restaurant density were both found to be unassociated with the consumption of fruits & vegetables, eliminating the exposure measures from the Baron and Kenny analysis. Step 3 was found to be significant for all measures, with greater vegetable consumption being associated with a reduction in the relative prevalence of diabetes after adjusting for the food environment measures. When comparing the relative prevalence from the primary Poisson regression model to the adjusted model in Step 3, limited attenuation of the relative prevalence was observed, with fast-food restaurant density seeing a 0.1% reduction in relative prevalence after adjusting for fruit & vegetable consumption. As it met all 4 Baron and Kenny criterion, fruit & vegetable consumption was found to be a partial mediator in the casual pathway between fast-food restaurant density and type II diabetes.

After stratifying by sex, similar associations were seen in the female population, with fruits & vegetables consumption only mediating the association between fast-food restaurant availability and diabetes prevalence. Step 1 through 3 were all found to be significant, with a 0.1% reduction in the relative prevalence being seen when comparing the unadjusted (Step 1) and adjusted model (Step 3). However, mediation was not observed in the male population, with no measures of the food environment meeting the requirements for Step 1. Furthermore, unlike the overall sample and female population, fruits & vegetables consumption was not associated with diabetes prevalence among males in Step 3.

5.3.2.2 Cardiovascular Disease and Hypertension Prevalence

Fruit & vegetable consumption was not found to be an intermediary variable on the pathway between any measure of the food environment and both cardiovascular disease and hypertension prevalence. No measures of the food environment were found to be significantly associated with cardiovascular disease or hypertension in Step 1, resulting in all measures failing to meet the initial mediation criterion outlined by Baron and Kenny. However, 2 measures of the food environment, the availability of fast-food restaurants and full-service restaurants, were significantly associated with fruit & vegetable consumption in both diseases. Furthermore, fruit & vegetable consumption was found to be inversely associated with only hypertension prevalence and not associated with cardiovascular disease prevalence in Step 3. Similar associations were seen in both genders, with the densities measures of the food environment not being associated with cardiovascular disease or hypertension prevalence in Step 1 after sex stratification. Due to Step 1 of the Baron and Kenny mediation analysis not being met either in the overall or sex-specific samples, fruit & vegetable consumption was determined to not be a mediator on the pathway between both hypertension and cardiovascular disease prevalence and the food environment.

Table 5.16 Summary of Baron Kenny Analysis: Fruits & vegetables Consumption in the Overall Study Population

Type II Diabetes					
Exposure	**Baron & Kenny Steps**				
Measures:	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	Yes	No	Yes	No	No
Fast-food Restaurants	Yes	Yes		Yes	**Partial**

Full-service Restaurants	No	Yes		No	No
Local and Non-chain Restaurants	Yes	No		No	No
Cardiovascular Disease					
Exposure Measures:	**Baron & Kenny Steps**				
	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	No	No	No	No
Fast-food Restaurants	No	Yes		No	No
Full-service Restaurants	No	Yes		No	No
Local and Non-chain Restaurants	No	No		No	No
Hypertension					
Exposure Measures:	**Baron & Kenny Steps**				
	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food	Does the exposure	Does the exposure	Does the mediator predict	In Step 3, is the association	

environment (per 10000 individuals)	predict outcome?	predict mediator?	outcome, after adjusted for exposure?	between exposure and outcome attenuated compared to step 1?	
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	Yes	No	Yes	No	No
Fast-food Restaurants	No	Yes		No	No
Full-service Restaurants	No	Yes		No	No
Local and Non-chain Restaurants	No	No		No	No

Table 5.17 Summary of Baron Kenny Analysis: Fruits & vegetables Consumption in the Male Study Population

Type II Diabetes					
Exposure	**Baron & Kenny Steps**				
Measures:	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	
Supermarkets and Large	No	No		No	No

Grocery Stores					
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	No	No	No	No
Fast-food Restaurants	No	Yes		No	No
Full-service Restaurants	No	Yes		No	No
Local and Non-chain Restaurants	No	No		No	No
Cardiovascular Disease					
Exposure Measures:	**Baron & Kenny Steps**				
	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	(No, Partial, Complete)
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	No	No	No	No
Fast-food Restaurants	No	Yes		No	No

Full-service Restaurants	No	Yes		No	No
Local and Non-chain Restaurants	No	No		No	No
Hypertension					
Exposure Measures:	**Baron & Kenny Steps**				
	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	
Supermarkets and Large Grocery Stores	No	No	Yes	No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	No		No	No
Fast-food Restaurants	No	Yes		No	No
Full-service Restaurants	No	Yes		No	No
Local and Non-chain Restaurants	No	No		No	No

Table 5.18 Summary of Baron Kenny Analysis: Fruits & vegetables Consumption in the Female Study Population

Type II Diabetes	
	Baron & Kenny Steps

Exposure Measures: The availability of the food environment (per 10000 individuals)	Step 1: Does the exposure predict outcome?	Step 2: Does the exposure predict mediator?	Step 3: Does the mediator predict outcome, after adjusted for exposure?	Step 4: In Step 3, is the association between exposure and outcome attenuated compared to step 1?	Mediator Status (No, Partial, Complete)
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	No	Yes	No	No
Fast-food Restaurants	Yes	Yes		Yes	**Partial**
Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	Yes	No		No	No
Cardiovascular Disease					
Exposure			**Baron & Kenny Steps**		
Measures: The availability of the food environment (per 10000 individuals)	Step 1: Does the exposure predict outcome?	Step 2: Does the exposure predict mediator?	Step 3: Does the mediator predict outcome, after adjusted for exposure?	Step 4: In Step 3, is the association between exposure and outcome attenuated compared to step 1?	Mediator Status (No, Partial, Complete)
Supermarkets and Large	No	No		No	No

Grocery Stores					
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	No	No	No	No
Fast-food Restaurants	No	Yes		No	No
Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	No	No		No	No
Hypertension					
Exposure Measures:	**Baron & Kenny Steps**				
	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	(No, Partial, Complete)
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	No	Yes	No	No
Fast-food Restaurants	No	Yes		Yes	No

Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	No	No		No	No

5.3.3 Physical Activity

5.3.3.1 Type II Diabetes

Physical activity levels were found to be partial mediators between three measures of the food environment and type II diabetes prevalence. In Step 1, which assessed the association between the measures of the food environment and diabetes prevalence, only 3 measures were found to be significantly associated with type II diabetes prevalence: the availability of small grocery and convenience store density, fast-food restaurant density, and local and non-chain restaurant density. In Step 2, which examined the association between the food environment measures and increasing levels of physical activity, all three of these measures were found to be associated with levels of physical activity as well. Step 3 also found to be significant, with increasing levels of physical activity being associated with a reduced relative prevalence of diabetes after adjusting for the measures of the food environment. When comparing the relative prevalence of the Poisson regression model to the adjusted model in Step 3, the availability of the local and non-chain restaurants was associated with slight attenuation in effect, with 0.1% increase in relative prevalence being observed after adjusting for activity levels. A very limited attenuation of the relative prevalence was observed with the density of fast-food restaurants, with a 0.02% reduction in relative prevalence being observed after adjusting for physical activity levels. A larger attenuation of relative prevalence was seen with small grocery and convenience store availability, albeit still small, with the risk of an individual having hypertension reducing by 0.3% after adjusted for physical activity level. As all 3 measures met the Baron and Kenny criterion, physical activity was found to be a partial mediator in the casual pathway between type II diabetes and fast-food restaurant density, local and non-chain grocery store density, and small grocery convenience store density.

These associations were not observed after stratifying the sample by sex. No mediation was observed within the male population, with the measures of the food environment failing to meet the significance requirements for Step 1. However, within the Step 1, both fast-food restaurant density and local and non-chain restaurant density were found to be significantly associated with diabetes prevalence in the female population. However, in Step 2, fast-food restaurant density was not found not to be associated with physical activity. Local and non-chain restaurants met the Baron and Kenny requirements at Step 4, with the relative prevalence of type II diabetes associated with local and non-chain restaurant density being attenuated by 0.1% after adjusting for physical activity levels. As a result, physical activity was found to only mediate the casual pathway between local and non-chain restaurants and diabetes in the female population.

5.3.3.2 Cardiovascular Disease and Hypertension Prevalence

Physical activity was determined not to be an intermediary variable on the casual pathway between the measures of the food environment and both cardiovascular disease prevalence and hypertension prevalence. No measures of the food environment were found to be significantly associated with cardiovascular disease or hypertension in Step 1, resulting in all measures failing to meet the initial mediation criterion outlined by Baron and Kenny. However, in Step 2, 5 measures of the food environment, the availability of intermediate grocery stores, small grocery and convenience stores, fast-food restaurants, full-service restaurants, and local and non-chain restaurants were all significantly associated with physical activity levels. Furthermore, physical activity was found to be inversely associated with both hypertension and cardiovascular disease prevalence in Step 3. Similar associations were seen in both genders, with the density measures of the food environment is not associated with cardiovascular disease or hypertension prevalence in Step 1 after sex stratification. Due to Step 1 of the Baron and Kenny mediation criterion not being met in the overall and gender stratified samples, physical activity level was determined not to be a mediator on the pathway between the food environment and both chronic conditions.

Table 5.19 Summary of Baron Kenny Analysis: Physical Activity in the Overall Study Population

Type II Diabetes					
Exposure			**Baron & Kenny Steps**		
Measures:	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	(No, Partial, Complete)
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	Yes		No	No
Small Grocery and Convenience Stores	Yes	Yes	Yes	Yes	**Partial**
Fast-food Restaurants	Yes	Yes		Yes	**Partial**
Full-service Restaurants	No	Yes		No	No
Local and Non-chain Restaurants	Yes	Yes		Yes	**Partial**
Cardiovascular Disease					
Exposure			**Baron & Kenny Steps**		
Measures:	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status
The availability of the food	Does the exposure	Does the exposure	Does the mediator predict	In Step 3, is the association	(No, Partial, Complete)

environment (per 10000 individuals)	predict outcome?	predict mediator?	outcome, after adjusted for exposure?	between exposure and outcome attenuated compared to step 1?	
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	Yes		No	No
Small Grocery and Convenience Stores	No	Yes	Yes	No	No
Fast-food Restaurants	No	Yes		No	No
Full-service Restaurants	No	Yes		No	No
Local and Non-chain Restaurants	No	Yes		No	No
Hypertension					
Exposure Measures:	**Baron & Kenny Steps**				
	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	Yes		No	No

Small Grocery and Convenience Stores	No	Yes	Yes	No	No
Fast-food Restaurants	No	Yes		No	No
Full-service Restaurants	No	Yes		No	No
Local and Non-chain Restaurants	No	Yes		No	No

Table 5.20 Summary of Baron Kenny Analysis: Physical Activity in the Male Study Population

Type II Diabetes					
Exposure	**Baron & Kenny Steps**				
Measures:	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	
Supermarkets and Large Grocery Stores	No	Yes		No	No
Intermediate Grocery Stores	No	Yes		No	No
Small Grocery and Convenience Stores	No	Yes	Yes	No	No
Fast-food Restaurants	No	No		No	No
Full-service Restaurants	No	Yes		No	No

Local and Non-chain Restaurants	No	Yes		No	No

Cardiovascular Disease					
Exposure	**Baron & Kenny Steps**				
Measures:	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	(No, Partial, Complete)
Supermarkets and Large Grocery Stores	No	Yes	Yes	No	No
Intermediate Grocery Stores	No	Yes		No	No
Small Grocery and Convenience Stores	No	Yes		No	No
Fast-food Restaurants	No	No		No	No
Full-service Restaurants	No	Yes		No	No
Local and Non-chain Restaurants	No	Yes		No	No

Hypertension					
Exposure	**Baron & Kenny Steps**				
Measures:	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status
The availability of the food environment	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after	In Step 3, is the association between exposure	(No, Partial, Complete)

(per 10000 individuals)			adjusted for exposure?	and outcome attenuated compared to step 1?	
Supermarkets and Large Grocery Stores	No	Yes		No	No
Intermediate Grocery Stores	No	Yes		No	No
Small Grocery and Convenience Stores	No	Yes	Yes	No	No
Fast-food Restaurants	No	No		No	No
Full-service Restaurants	No	Yes		No	No
Local and Non-chain Restaurants	No	Yes		No	No

Table 5.21 Summary of Baron Kenny Analysis: Physical Activity in the Female Study Population

Type II Diabetes					
Exposure	**Baron & Kenny Steps**				
Measures:	Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	(No, Partial, Complete)
Supermarkets and Large Grocery Stores	No	No		No	No

Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	Yes	Yes	No	No
Fast-food Restaurants	Yes	No		No	No
Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	Yes	Yes		Yes	**Partial**

Cardiovascular Disease

Exposure Measures: The availability of the food environment (per 10000 individuals)	**Baron & Kenny Steps** Step 1: Does the exposure predict outcome?	Step 2: Does the exposure predict mediator?	Step 3: Does the mediator predict outcome, after adjusted for exposure?	Step 4: In Step 3, is the association between exposure and outcome attenuated compared to step 1?	Mediator Status (No, Partial, Complete)
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	Yes	Yes	No	No
Fast-food Restaurants	No	No		No	No
Full-service Restaurants	No	No		No	No

Local and Non-chain Restaurants	No	Yes		No	No
Hypertension					
Exposure Measures:	**Baron & Kenny Steps** Step 1:	Step 2:	Step 3:	Step 4:	Mediator Status (No, Partial, Complete)
The availability of the food environment (per 10000 individuals)	Does the exposure predict outcome?	Does the exposure predict mediator?	Does the mediator predict outcome, after adjusted for exposure?	In Step 3, is the association between exposure and outcome attenuated compared to step 1?	
Supermarkets and Large Grocery Stores	No	No		No	No
Intermediate Grocery Stores	No	No		No	No
Small Grocery and Convenience Stores	No	Yes	Yes	No	No
Fast-food Restaurants	No	No		No	No
Full-service Restaurants	No	No		No	No
Local and Non-chain Restaurants	No	Yes		No	No

Chapter 6

6 Discussion

6.1 Summary of Findings

The main objective of this thesis was to examine the contextual influence of the neighbourhood food environment on three chronic diseases in urban Canada. In order to assess this relationship, neighbourhood level food outlets, at the Forward Sortation Area level, were categorized into 6 density measures representing the availability of food outlets within the surrounding vicinity: supermarkets and large grocery stores, intermediate grocery stores, small grocery and convenience stores, fast-food restaurants, full-service restaurants, and local and non-chain restaurants. Using a modified Poisson regression, these measures were then examined against three chronic conditions: prevalence of type II diabetes, cardiovascular disease, and hypertension.

The results of the study found that a greater availability of fast-food restaurants was positively associated with an elevated prevalence of type II diabetes while a greater availability of local and non-chain restaurants was negatively associated with type II diabetes among adults in urban Canada. These associations persisted in both population-based (per 10000 population) and area-based (per km^2) measures of the food outlets even after adjusting for neighbourhood level covariates and demographic, socioeconomic, and lifestyle confounders. However, after stratifying the analysis by sex, statistically significant associations were only found in the female sample. Further analyses suggested that weight class, fruits & vegetables consumption, and physical activity were partial mediators in the pathway between fast-food restaurants and type II diabetes prevalence, while weight class and physical activity were found to be partial mediators in the pathway between local and non-chain restaurants and diabetes. No associations were found between the food environment and cardiovascular disease or hypertension prevalence. However, inconsistent associations were observed within both food environment density measures in both sexes.

This study built on the current body of literature in which researchers are beginning to examine the contextual effects of the built environment on health related outcomes. While the relationship between the food environment and obesity is studied in the literature, the association between the neighbourhood food environment and chronic disease is limited. This study represents the first to examine the association between the food environment and the prevalence of cardiovascular disease, type II diabetes, and hypertension in a Canadian context. Furthermore, the formal assessment of weight class, dietary patterns, and physical activity as potential mediators is a novel approach. Very few studies have assessed the role of mediation in this context, with this study being the first to do so using a formal mediation analysis in the Canadian setting.

While only a limited number of significant associations were observed, the confidence in the finding of the associations between both fast-food restaurants and local and non-chain restaurants density and diabetes is increased because these associations occur in population-based (per 10000 individuals) and area-based (km^2) measures, reducing the likelihood that the observed associations were due to chance. Furthermore, the use of multiple measures of food outlet availability with the analysis allowed for the assessment of the food environment as whole, with the inclusion of these variables adjusting for the contextual influence of the presence of these food stores.

6.2 Interpretation of Findings

The results of the analysis found limited evidence of an association between the neighbourhood food environment variables and type II diabetes. After adjusting for confounders, covariates, and potential mediators, fast-food restaurant density was found to be positively associated with diabetes prevalence in both the population-based (per 10000 FSA population) (RP: 1.019; 95% CI: 1.004 - 1.034) and area-based (per FSA km^2) (RP: 1.086; 95% CI: 1.022 - 1.155) density measures. Furthermore, local and non-chain restaurant density was inversely associated with the prevalence of diabetes, with these association being seen in both the population-based (per 10000 FSA population) (RP: 0.987; 95% CI: 0.979 - 0.996) and area-based (per FSA km^2) (RP: 0.969; 95% CI: 0.940 - 0.999) density measures. The lower limits of reported confidence intervals, nevertheless, bring into question the clinical significance of these findings, with these values being very close to the null. However, as these associations were seen in both types of density measures, it is likely that the observed associations are unlikely due to chance.

The positive association seen between fast-food restaurant density and diabetes is consistent with the literature. Both Ahern *et al.* (56) and Salois (53) found a positive association between fast-food availability and the self-reported prevalence of diabetes in a US wide county level analysis. Other studies have reported inconsistent findings, with Stewart *et al.* (60) reporting no statistically significant associations and Holmes & Thompson (59) finding a negative association. However, the comparability of these studies is limited as Stewart *et al.* (60) restricted their sample to African Americans while Holmes & Thompson (59) assessed for correlation rather than association. Similar inconsistencies were seen with the other measures of the food environment. Ahern *et al.* (56) and Salois (53) both reported a negative association between the full-service restaurant density and the prevalence of diabetes, while both supermarkets and grocery store availability were inversely associated with diabetes risk (44,56,59). However, all these measures were observed to be statistically non-significant with diabetes prevalence in this study, with no associations seen between diabetes prevalence and the availability of supermarkets and large grocery stores, intermediate grocery stores, small grocery and convenience stores and full-service restaurants.

It is noteworthy that the association between fast-food availability and diabetes was only seen in the female population, suggesting that the surrounding food environment may influence women more adversely than men. While not previously assessed in the context of the food environment and chronic disease, similar sex disparities in the association between fast-food availability and BMI have been reported in the literature (140,141). Behavioural differences between the genders in both work and dietary patterns could explain this disparity, with an increased presence of females within the workforce in the last few decades resulting in an increased reliance on convenience and hence fast-food options. These factors could be further exacerbated due to distinct physiological changes in both sexes with increasing age.

For the sake of simplicity, it was hypothesized that supermarkets, grocery stores, and full-service restaurants availability were inversely associated with diabetes prevalence as they provided access to healthy foods, while small grocery stores and convenience stores availability was associated with increased prevalence of diabetes. This generalization, however, understates the availability of a wide range of food products offered at these locations. While considered a primary source of healthy food products in the literature, supermarkets and grocery stores typically provide access to a wide variety of both healthy and unhealthy foods (392,461). While these locations are able to provide healthy foods at a reduced cost compared other food store locations (362,462), the availability and access to both healthy and unhealthy food products in these stores makes it increasingly difficult to discern the effect these stores have on diet and health. Similar trend occur in convenience stores, small grocery stores, and full-service restaurants, with these locations providing access to healthy foods, such as fruits and vegetables, while providing unhealthy options, although to a smaller extent (112,463,464). Fast-food restaurants, however, provide mainly caloric dense and energy rich food options at a reduced cost and large portion size, having a more direct influence on health adversely. This simplification is applicable to the other chronic conditions, as the large numbers of statistically non-significant associations were seen with hypertension and cardiovascular disease.

No significant associations were found between cardiovascular disease prevalence and the local food environment. These findings did not lend support to the hypotheses being tested and are inconsistent with the results reported in the current literature. Of the three studies that have assessed the relationship between the food environment and cardiovascular disease, two were conducted in Canada. Alter & Eny (68) and Daniel *et al.* (66) found that the availability of fast-food restaurants was positively associated with cardiovascular disease outcomes. The associations between supermarket density and cardiovascular disease was ambiguous, with Daniel *et al.* (66) finding no significant association between cardiovascular disease and availability of fruits & vegetables stores availability, while Naveed (72) found a positive association with myocardial infarction. This discrepancy between the literature and results of this study, however, may be a result of the difference in how cardiovascular disease was defined. The previous literature defined cardiovascular disease as the incidence of specific cardiovascular outcomes, with both Daniel *et al.* (66) and Alter & Eny (68) using incidence and mortality rates of acute coronary syndromes as their outcome measure while Naveed (72) defined the outcome measure as the incidence of myocardial infarction events. These incidence and mortality rates were ascertained using medical health records, which is more reliable than the 2009-2010 CCHS self-reported data on cardiovascular disease prevalence.

Hypertension was not found to be associated with the measures of the food environment with one exception. When the food environment was assessed through area-based density measures (per FSA km^2), the availability of fast-food restaurants per km^2 was found to be inversely associated with hypertension prevalence (RP: 0.952; 95% CI: 0.913 - 0.993), suggesting a possible protective effect. This result was only observed after adjusting for the covariates and confounders (Model 3), implying that this result may be due to the inclusion of a possible covariate or confounder into the model. Similar associations were seen after the analysis was stratified by sex. After adjusting for the covariates and confounders (Model 3), the availability of local and non-chain restaurants positively associated with hypertension prevalence in the male population (RP: 1.024; 95% CI: 1.006 - 1.042), while fast-food availability was negatively associated (RP: 0.936; 95% CI: 0.884 - 0.991) and full-service restaurant availability positively associated with hypertension in the female population (RP: 1.240; 95% CI: 1.002 - 1.535). The observed associations were all in the contradictory and opposite direction to findings in the literature. While negatively associated in this study, fast-food restaurant density is commonly found to be positively (63,65) or no association (64) with hypertension, while supermarket density has been found to be negatively (44,64) or not associated (65) with hypertension. Furthermore, the findings were only seen in the area-based density measures, with no significant associations seen with population-based (per 10000 FSA population) density, reducing the strength of the evidence due to a lack of consistency.

Differences in disease prevalence in the study population may also have played a role in this analysis. Type II diabetes and cardiovascular disease prevalence were both found to be rare in the final study sample, with both disease prevalent in less than 10% of the population. Conversely, the prevalence of hypertension was common, with the condition being seen within greater than 20% of the population. A modified Poisson regression model was used as it allowed for the estimation of relative prevalence regardless of the rare outcome. While many studies have used odds ratios in order to estimate risk, it could be avoided in this study because of the relative abundance of hypertension. The odds ratio is able to approximate the relative prevalence only when the outcome is considered rare in the population (<10%), with the estimates being inflated and further from than null when the prevalence of the outcome is common (456). Using a modified Poisson regression allowed an easier interpretation of the relative prevalence.

The mediation analysis found some evidence of partial mediation in the pathway between the food environment and chronic disease. The Baron and Kenny criterion for mediation was only met for two of the measures of the food environment with the prevalence of type II diabetes. Weight class, fruits & vegetables consumption, and physical activity levels were all found to partially mediate the association between fast-food restaurant density and type II diabetes. Only weight class and physical activity levels were partial mediators on the pathway between local and no-chain restaurant availability and diabetes prevalence. It is noteworthy that these variables were only partial mediators, suggesting that an underlying direct relationship between the fast-food environment and chronic disease prevalence persists even though additional intermediate pathways are present.

No mediation was seen between the food environment and the prevalence of both hypertension and cardiovascular disease as there was no underlying association to be meditated. A large majority of the results failed to meet the requirements at Step 1 of the mediation analysis (i.e. no associations found between the exposure measures and the outcome measures). While many of these measures did meet the requirements for Step 2, which assessed if the exposure predicted the mediator, and Step 3, that the mediator predicted the outcome while adjusting for the exposure, the lack of a discernible direct pathway between the exposure and outcome measures resulted in the failure to meet the requirements for mediation analysis.

Previous literature examining the role of potential mediators in the casual pathway between the food environment and health related outcomes is very limited. While Auchnicloss *et al.* (69) did find evidence of potential meditation from BMI, physical activity, and dietary patterns in the association between the food environment and insulin resistance, their study used a perceived measure of neighbourhood healthiness to define the food environment, limiting comparability. Dubowitz *et al.* (64) also found limited evidence of physical activity partially mediating the association between hypertension and the availability of fast-food, however, no formal mediation analysis was undertaken to derive this conclusion. The existence of these intermediate pathways represents a finding novel to the literature.

Another possible explanation for the lack of associations was the age restrictions applied to the sample population. The majority of studies in the current literature have assessed the effects of obesity and food environment on the adult population aged 18 to 65. The sample of this study, however, was restricted to individuals between the years of 35 and 75 in order to better capture the age group at the risk for chronic diseases. As increasing age has been associated changes in biological mechanisms, resulting in lowered metabolism and increased fat acclimation, the effects of the food environment may be limited within the older individuals. However, recent studies have found that increased BMI and obesity risk has been associated with the availability of fast-food restaurants in older adults as well (465,466), suggesting that an association between the food environment and obesity may still persist in older age.

The inclusion of the local and non-chain restaurant and the intermediate grocery store density measures was a novel approach used in this study. These measures adjusted the analysis for the exposure to the restaurants and grocery stores that could not be identified as providing fast-food or full-service, or as supermarket and large grocery stores or small grocery stores locations. As these outlets represented the bulk of locations available through the secondary database, doing so allowed for a holistic measure of the local food environment. This allowed for the assessment of the contextual influence of each food outlet measure within the food environment as a whole, enabling a comparison of risk relative to the availability of other food outlets.

6.3 Strengths and Limitations

All the data included in this study was representative of the year 2010 which is a major strength. The use of the CCHS and the CFM Leads database allowed for relatively accurate and validated collection of data on food outlets across Canada. The CFM Leads database claims that their data are up to 85%-95% accurate, with food outlets being frequently run through the National Change of Address (NCOA) database and being cross checked with new movers to ensure the information provided is recent (426). The 2011 CFM Leads dataset was also cleaned and validated before constructing the exposure measures, with missing and misclassified outlets being removed to ensure data quality. The CCHS also provided a nationally representative sample to examine the association between the neighbourhood food environment and chronic disease among adults in urban Canada, creating a large overall sample. One of the key weaknesses of the Baron and Kenny mediation analysis is the low statistical power of the test. However, due to large sample size, this was a relatively not an issue (460).

Furthermore, the availability of the food environment was assessed through both area-based (calculated as the number of outlets per km^2 within each FSA) and population-based (calculated as the number of food outlets per 10000 FSA population) density measures. The use of two measures of availability allowed for a more thorough assessment of the relationship between the neighbourhood food environment and chronic disease, enabling the comparison of any observed associations across both measures for consistency. This ability to check for consistency strengthened the evidence of the significant associations, thus reducing the likelihood that the findings were due to random chance.

The inclusion of multiple measures of food outlet availability also allowed for a comprehensive assessment of these outlets in the context of the food environment. The majority of papers in the literature have restricted their analyses of the food environment to either a single or limited number of outlet measures. Doing so, however, limits the assessment of the food environment in its entirety, which can introduce confounding bias into the analysis (467). An individual’s decision to access a food store is influenced not only by personal choice, but the availability and diversity of multiple types of outlets in the surrounding vicinity. Focusing solely on individual measures of availability ignores the influence of the variety of these locations on choice, preventing the assessment of the broader food environment. To this end, two separate variables measuring the availability of intermediary grocery stores and local and non-chain restaurant locations were included in the models. While discerning the type of services these food outlets provided was not feasible in the scope of the study, these locations did comprise a large number of food stores found in the CFM Leads database. Adjusting for their influence provided a more robust measure of the food environment. The inclusion of multiple measures of the food environment in the analysis is not without limitations. Density measures of food outlets have been found to be highly correlated (468) and may increase the risk of multicolinearity when all these measures are included in a regression model (467).

A limitation of this study was its cross-sectional design. Cross-sectional studies provide a "snapshot" assessment at a point of time and lack the ability to establish temporality between the exposure and outcome. A lack of temporality limits the ability to infer causation (469). Future research can examine if these associations persists over time through the implementation of longitudinal study design or repeated cross-sectional design if longitudinal data are available.

The self-reported nature of the primary outcome measures was also a concern. Specifically, self-reported disease in survey data such as the CCHS have been found to have a significant response error, resulting in large attenuation biases (470,471). Differences in the construction of the variables used to derived disease prevalence may have further resulted in accuracy issues between chronic disease outcomes. Type II diabetes prevalence was ascertained through the derived variable CCCDDIA. CCCDIA determined diabetes type through a series of multiple health related questions, such as type of medication used and age of diagnosis, allowing for a more accurate diagnosis. However, the prevalence of cardiovascular disease (CCC_121) and hypertension (CCC_071) were determined using responses to a single question. Confirmed diagnoses of each of the chronic diseases through individual medical records would have allowed for the accurate assessment of chronic disease outcome in this study. However, the lack of availability of data for a nationally representative sample of Canadians made doing so unfeasible.

Although an error correction factor proposed by Gorber *et al.* (443) was used to adjust BMI values, the use of BMI as a measure of adiposity is still an issue. The reason being that BMI is unable to distinguish between body fat and lean muscle (472). While more accurate measures exist in the literature, BMI remains the most commonly used method to measure adiposity in the population. Furthermore, accurate assessment of body fat for a nationally representative sample was not available.

The geographic scale used to define neighbourhoods in this study was also a point of contention. Ideally speaking, accurately measuring the exposure of the local food environment requires capturing each participant's activity space based on GPS tracking data. But this was not feasible, as it is time consuming and costly. Thus, FSAs, a type of administrative area unit, was used as a proxy for neighbourhoods. However, there exist two major caveats for using FSA as a proxy for neighbourhoods. Firstly, defining neighbourhoods through proxies limited the ability to measure the exposure of food outlets in close by neighbouring areas, which is known as the edge effect in the geographical literature. Individuals that reside near the administrative borders of their respective neighborhoods are more likely to use nearby food stores in neighboring areas due to increased accessibility. As these stores fall outside of the boundaries of the administrative areas, they are not accounted for when measuring the food environment, leading to an underestimation of the exposure (84). Very few studies have adjusted for the edge effect, although a study by Sadler *et al.* (85) found that after buffering neighbouring counties to adjust for bordering neighbourhoods, traveling distances to closest grocery store and fast-food stores significantly decreased. While a few individuals within the sample population may be affected by the edge effect, there is no evidence to suggest that this could introduce large bias into the study. The CCHS sampled a large number of individuals across Canada, and it is reasonable to assume that the study participants and their corresponding postal codes are randomly distributed in their respective FSAs rather than clustered around these administrative borders.

Secondly, in order to categorize the sample population into their respective FSAs, residential addresses, defined through postal codes, were used. The food environment, however can extend past the immediate residential surroundings, extending into the travel behaviors/routes and non-residential places of activity outside of a residential address, otherwise known as an individual's activity space (80,81). Activity spaces are important to consider as an individual engages in a variety of activities within a network of commonly visited places outside of their residence on a daily basis, such as schools, work places, and commonly traveled routes (81,82). As a result, available resources around these areas, such as different food stores, may be accessed with greater frequencies, due to increased convenience and accessibility, while being several miles away from their residential address (79). This can result in the underestimation of the exposure to the food environment when only the local environment is considered (47,473). Failing to adjust for this can result in falling into the "local" trap (79), narrowing the scope of total geographic exposure due to a heavier focus on the immediate area surrounding the residential address. The use of FSAs, however, adjusts for activity space to some extent, as they are geographically large enough to capture and incorporate some aspects of travel routes and work places. Future studies can work on capturing the full exposure to food environment by collecting data on daily activities of individuals through GPS tracking (83).

Another limitation is the use of the CFM Leads 2011 database, a secondary data source, to collect food environment data. Despite their best efforts to ensure data accuracy, secondary databases are prone to misclassification and measurement errors, ranging from reporting errors to clerical errors (92,93), thus reducing the accuracy and validity of their lists (91,94). Primary databases, created through direct observation and manual data collection, can provide a more accurate collection of food stores (95), however the availability of such resources at a national level is limited. Constructing these measures for a large scale study is both time consuming and resource intensive, making it impractical for research use (91).

In order to reduce the influence of misclassification errors, two broad strategies were employed. First, individuals living in rural areas were excluded from the analysis, an approach that has been used in previous studies (101,432,433,449). Food outlets data in rural areas is often misclassified or missing in secondary databases due to difficulties in data collection compared to their urban counterparts (96,179). Another method used to address the misclassification was the combination of published retail chain directory lists for food outlet names and characteristics available in the CFM Leads database. The CFM Leads database did provide SIC codes, a type of classification code commonly used in order to categorize food outlets into their respective stores types. However, the use of SIC codes solely to categorize food outlets has been found to be unreliable, as errors in data collection often results in the misclassification. Retail directory lists provided up to date information of the names and traits of chain food outlets across Canada, allowing for an accurate identification and categorization of these outlets based on the types of services they provide. Furthermore, as these locations are franchised, they are likely to provide similar goods and services regardless of the geographic location. The use of store characteristics in conjunction with SIC codes to categorize food outlets were found to be more robust categorization of food outlets than when a single characteristic is used as shown in previous studies (101,393,439,440). A problem with of this approach, however, was the exclusivity of the directory lists and store characteristics, which allowed for the identification and classification of a small number of outlets in the CFM Leads database. Intermediate grocery store and local and non-chain restaurants comprised the bulk of the outlets in the CFM Leads database. I categorized these outlets into two separate variables and included them in the analysis to adjust for their effect.

Another potential limitation is the oversimplification of the types of services provided by different types of food outlets. For the sake of simplicity, the health and dietary effects of different food outlets was hypothesized based on the type of food products and services these locations generally provide. However, such generalization can understate the availability of a wide range of both healthy and unhealthy food products offered at these locations (392). Furthermore, based on geographic location and urban development, the same type of food locations in different neighbourhoods can carry widely different food products (362). Thus, it is increasingly difficult to truly discern the true effect of these food stores on health and diet. Variations in food quality can only be properly assessed through micro level assessments of food environment, focusing more on individual perspective rather than neighbourhood exposure. Micro level assessments use a variety of store auditing tools to measure individual level availability, variety, pricing, quality, promotion and placement of food products in each food store (474). Recent studies suggest using a combination of both macro (neighbourhood) and micro (individual) level food environment measures to create a more comprehensive measure of the neighbourhood food environment (26,474). However, due to the large number and variability of food products within each food store, the feasibility of doing so for a large scale population study is limited. While micro level assessments of the food environment were generally unavailable for this study, adjustments were made for individual level fruits & vegetables consumption in the regression analysis. While not as precise, this variable was able to act as a proxy for individual dietary patterns to some extent, reflecting the availability of these foods in the surrounding environment.

6.4 Study Implications and Future Research

The results of the study found limited evidence of an association between the food environment and chronic disease. In the context of the neighbourhood food environment in Canada’s urban jurisdictions, fast-food restaurant availability was found to be positively associated with type II diabetes prevalence in adults. Furthermore, weight class, fruits & vegetables consumption, and physical activity partially mediated the pathway between fast-food restaurant availability and type II diabetes prevalence. No statistically significant associations between the food environment and cardiovascular disease or hypertension were observed in this study, contrary to the results in the previous literature. This study is the first to examine the association of the food environment with prevalence of diabetes and hypertension in Canada. Moreover, this is the first study to assess the role of potential mediators (weight class, fruits & vegetables consumption and physical activity) in the relationship between the food environment and chronic disease.

Future work can build upon this study to investigate the causal effect of the food environment on prevalence and incidence of chronic diseases. Incorporating a longitudinal design would allow for the assessment of temporality between the food environment and chronic disease, which would eliminate potential unknown confounders and help move closer to the causal association. Food environment measures capturing an individual’s activity space through GPS tracking data would allow for a better measurement of exposure compared to the area level proxies used in this study and commonly throughout the literature. These food environment measures could be further supplemented with micro-level assessments of food store quality at both the individual and community level. Furthermore, the use of medical records from health administrative databases would provide accurate data on the prevalence or incidence of chronic diseases in the population.

The implications of these findings can help inform future policies and intervention aimed at stemming the rise of chronic disease and obesity in Canada. These policy recommendations should not be directly followed from the results of this study, but rather can be used as policy options to be considered by public health authorities to direct future legislation. Current policies regarding the food environment has targeted the community level, aimed at increasing the availability and awareness of knowledge of unhealthy foods. While laws requiring pre-packaged food products display nutritional information exist in Canada, the display of nutritional contents in restaurants or fast-food outlets are not available in all establishments (475). There have been some case studies on this topic. For instance, in 2008 New York introduced changes to local restaurant regulations and a ban on transfats, which resulted in a significant reduction in the purchase of foods with high transfats at fast-food chains without a substantial increase in saturated fat consumption (476). Furthermore, the United States Food and Drug Administration (FDA) passed federal regulation in 2010 that required restaurant chain with greater than 20 locations to provide calorie labeling on all menus and menu boards in order to increase access to nutritional knowledge (477). The efficacy of interventions promoting nutritional information in restaurants, however, remains ambiguous. While some studies have found that calorie labeling on menus has been associated with no changes (478–480), many other have reported a significant decrease in caloric intake (481–486). For example, in a

Canadian study by Vanderlee and Hammond (475), the presence of nutritional information on a menus in a hospital cafeterias was associated with reduced intake of calories, sodium, saturated fat and total fat intake.

While these interventions may increase awareness and knowledge influencing food choice, the presentation of this nutritional information does not directly address the association of the availability of fast-food restaurants addressed in this thesis. To this effect, other polices have taken a more direct approach, aiming their intervention at limiting and even banning the supply and availability of fast-food locations through zoning bylaws. A very limited number of cities have adopted the use of zoning regulations in order to change the food environment. Legislation passed within Detroit, for example, required that a minimum distance of 500 feet exist between fast-food outlets and schools (487), while in 2008, Los Angeles passed a one year ban on expanding or opening of fast-food restaurant in South Los Angeles (488). Similar strategies have been implemented in a Canadian setting. Quebec has implemented zoning legislation against fast food restaurants near schools in Baie-Saint-Paul, Gatineau, and Lavaltrie through a framework established by the Association Pour La Sante Publique Du Quebec (489), while similar recommendations have been proposed in Alberta (490). Other provinces have taken different approaches, banning the sale and availability of unhealthy food products within schools. In 2011, Ontario prohibited the sale of the fast foods and sugary beverages in schools through the New School Food And Beverage Policy (491), while British Columbia implemented a similar ban through the Guidelines for Food and Beverage Sales in BC Schools in 2005 (revised in 2013) (492). Although these interventions would directly affect fast-food availability, a recent study by Raine *et al.* (493) in 2014, which assessed attitudes towards potential policy changes, found that policymakers are much less likely to endorse restrictive environmental policies requiring legislative change due to reduced tax revenue, hindering their implementation.

The results of the mediation analysis showed that individual-level behavioural and lifestyle variables, such as weight class, physical activity and fruits & vegetables consumption, represent possible pathways through which the food environment can influence chronic disease risk. Policies and education based prevention strategies aimed at modifying these individual behaviours, through the promotion of increased awareness and knowledge with regards to health, have had limited success (494–496). As a result, recent studies have called for a multifaceted approach towards policy and legislation (496). Policies should aim to focus on changes at both the community level, directed towards limiting neighbourhood accessibility of unhealthy foods and individual-level lifestyle and behavioural factors.

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Appendices

Appendix A: Canadian Community Health Survey Variable Breakdown and Construction

Table A.1 Construction of Outcome and Mediating Variables

Variable	Variable Name	Question	Response	Code	Recoded categories	Recoded variables	Recoded value	Additional edits and removed variables
FVCGTOT	Daily consumption - total fruits and vegetables	Derived variables based on FVCDTOT (Daily consumption: total frequency of fruits and vegetables)	Low: Less than 5 times/servings per day	1	Low	FVCGTOT = 1	0	FVCGTOT = 9
			Medium: 5 to 10 times/ servings a day	2	Medium	FVCGTOT =2	1	
			High: More than 10 times/servings per day	3	High	FVCGTOT = 3	2	
			Not Stated	9				
HWTDBMI	Body Mass Index	Derived variable from self-report height (HWTDHTM) and weight (HWTDWTK)	BMI	8.07-134.67	Under and normal weight	HWTDBMI < 25	0	Self-reported BMI correction $BMI_{(Males)} = -1.08 + 1.08*(HWTDBMI)$ $BMI_{(Females)} = -0.12 + 1.05*(HWTDBMI)$
			Not Applicable	999.96	Overweight	$25 \leq HWTDBMI < 30$	1	
			Not Stated	999.99	Obese	$HWTDBMI \geq 30$	2	

								HWTDBMI= 999.96 HWTDBMI= 999.99
HWTDISW	Body Mass Index	Derived variable created	Underweight	1	Under and normal weight	HWTDISW = 1 HWTDISW = 2	0	HWTDISW =96 HWTDISW =99
			Normal Weight	2				
			Overweight	3	Overweight	HWTDISW = 3	1	
			Obese- Class I	4				
			Obese- Class II	5	Obese	HWTDISW = 4 HWTDISW = 5 HWTDISW = 6	2	
			Obese- Class III	6				
			Not Applicable	96				
			Not Stated	99				
CCCDDIA	Diabetes type	Derived variable based on CCC_10B (Diabetes diagnosed: when not pregnant), CCC_10C (Diabetes diagnosed: when was insulin started), CCC_101 (has diabetes), CCC_102 (age diagnosed), CCC_105 (currently taking insulin), CCC_106 (takes pills to control blood	Type 1	1	Diabetes	CCCDDIA = 2	1	CCCDDIA = 1 CCCDDIA = 2 CCCDDIA = 4 CCCDDIA = 9
			Type 2	2				
			Gestational	3	No diabetes	CCCDDIA = 6	0	
			Could not be classified	4				
			Not applicable	6				
			Not stated	9				

		sugar), and DHH_AGE						
CCC_121	Has heart disease	Do you have heart disease?	Yes	1	Cardiovascular disease	CCC_121=1	1	CCC_121=7 CCC_121=8 CCC_121=9
			No	2				
			Don't know	7	No cardiovascular disease	CCC_121=2	0	
			Refusal	8				
			Not stated	9				
CCC_071	Has high blood pressure	Do you have high blood pressure?	Yes	1	Hypertension	CCC_071=1	1	CCC_071=7 CCC_071=8 CCC_071=9
			No	2				
			Don't know	7	No Hypertension	CCC_071=2	0	
			Refusal	8				
			Not stated	9				

Table A.2 Construction of Demographic Confounders

Variable	Variable Name	Question	Response	Code	Recoded categories	Recoded variables	Recoded value	Removed variables
DHH_AGE	Age	What is your age?	Years	12-102	N/A	N/A	N/A	35 ≤ DHH_AGE
DHH_SEX	Sex	Is respondent male or female?	Male	1	N/A	N/A	N/A	N/A
			Female	2				
SDCDCGT	Cultural / racial background	Derived variable based on SDC_43A(Racial origin: White), SDC_43B (Racial origin: Chinese), SDC_43C (Racial origin: South Asian),	White	1	Caucasian	SDCDCGT = 1	0	SDCDCGT = 96 SDCDCGT = 99
			Black	2				
			Korean	3	Visible minority	SDCDCGT = 2 SDCDCGT = 3 SDCDCGT = 4 SDCDCGT = 5	1	
			Filipino	4				
			Japanese	5				

		SDC_43D (Racial origin: Black), SDC_43E (Racial origin: Filipino), SDC_43F (Racial origin: Latin American), SDC_43G(Racial origin: South East Asian), SDC_43H (Racial origin: Arab), SDC_43I (Racial origin: West Asian), SDC_43J (Racial origin: Japanese), SDC_43K (Racial origin: Korean), SDC_43L, SDC_43M (Racial origin: Other)	Chinese	6		SDCDCGT = 6 SDCDCGT = 7 SDCDCGT = 8 SDCDCGT = 9 SDCDCGT = 10 SDCDCGT = 11 SDCDCGT = 12 SDCDCGT = 13		
			South Asian	7				
			Southeast Asian	8				
			Arab	9				
			West Asian	10				
			Latin American	11				
			Other Racial or Cultural Origins	12				
			Multiple Racial/ Cultural Origins	13				
			Not Applicable	96				
			Not Stated	99				
SDCFIMM	Immigrant	Derived variable based on SDC_3 (Year of immigration to Canada)	Yes	1	Canadian born	SDCFIMM = 2	1	SDCFIMM= 9 SDCDRES = 999
			No	2				
			Not stated	9	Immigrant: 0-10 years in Canada	SDCFIMM= 1 SDCDRES ≤ 10		
SDCDRES	Length of time in Canada since Immigration	Derived variable based on SDC_3 (Year of immigration to Canada) and ADM_YOI (Year of interview)	Years	0-97				
			Not Applicable	996	Immigrant: 11 or more years in Canada	SDCFIMM=1 SDCDRES > 10		
			Not Stated	999				

Table A.3 Construction of Socioeconomic Cofounders

Variable	Variable Name	Question	Response	Code	Recoded categories	Recoded variables	Recoded value	Additional edits and

								removed variables
DHH_MS	Marital Status	What is your marital status? Are you married, living common-law, widowed, separated, divorced, or single, never married?	Married	1	Married/Common-law	DHH_MS=1 DHH_MS=2	0	DHH_MS=97 DHH_MS=98
			Common-law	2				
			Widowed	3	Widowed/Separated/Divorced	DHH_MS=3 DHH_MS=4 DHH_MS=5	1	
			Separated	4				
			Divorced	5				
			Single, Never Married	6	Single/Never married	DHH_MS=6	2	
			Don't know	97				
			Refusal	98				
INCDHH	Total household income from all sources	Derived variable based on INC_3 (Total household income - best estimate), INC_5A (Total household income – Ranges), INC_5B (Household income - Range 1), and INC_5C (Household income - Range 2)	No income	1	Total income between $0-$9,999	INCDHH=1 INCDHH=2 INCDHH=3	0	INCDHH=99
			Less than $5,000	2				
			$5,000 to $9,999	3				
			$10,000 to $14,999	4	Total income between $10,000-$19,999	INCDHH=4 INCDHH=5	1	
			$15,000 to $19,999	5				
			$20,000 to $29,999	6	Total income between $20,000-$29,999	INCDHH=6	2	
			$30,000 to $39,999	7	Total income between $30,000-$39,999	INCDHH=7	3	
			$40,000 to $49,999	8	Total income between $40,000-$49,999	INCDHH=8	4	
			$50,000 to $59,999	9	Total income between	INCDHH=9	5	

					$50,000-$59,999			
			$60,000 to $69,999	10	Total income between $60,000-$69,999	INCDHH=10	6	
			$70,000 to $79,999	11	Total income between $70,000-$79,999	INCDHH=11	7	
			$80,000 to $89,999	12	Total income of $80,000 and up	INCDHH=12 INCDHH=13 INCDHH=14	8	
			$90,000 to $99,999	13				
			$100,000 or more	14				
			Not stated	99				
EDUDR04	Highest level of education – respondents, 4 levels	Derived variable based on EDU_1 (What is the highest grade of elementary or high school you ever completed), EDU_2 (Did you graduate from high school (secondary school)?), EDU_3 (Have you received any other education that could be counted towards a degree, certificate or diploma from an educational institution?), and	Less than secondary school graduation	1	Less than secondary school education	EDUDR04=1	0	EDUDR04=9
			Secondary school graduation	2	Secondary school education	EDUDR04=2	1	
			Some post-secondary	3	Some post-secondary	EDUDR04=3	2	
			Post-secondary graduation	4	Post-secondary graduation	EDUDR04=4	3	
			Not stated	9				

		EDU_4 (What is the highest degree, certificate or diploma have you obtained?)						
INCDRCA	Household income distribution	Derived variable based on INCDADR (Adjusted household income ratio)	Decile 1	1	Decile 1 and 2	INCDRCA=1 INCDRCA=2	0	INCDRCA=96 INCDRCA=99
			Decile 2	2				
			Decile 3	3	Decile 3 and 4	INCDRCA=3 INCDRCA=4	1	
			Decile 4	4				
			Decile 5	5	Decile 5 and 6	INCDRCA=5 INCDRCA=6	2	
			Decile 6	6				
			Decile 7	7	Decile 7 and 8	INCDRCA=7 INCDRCA=8	3	
			Decile 8	8				
			Decile 9	9	Decile 9 and 10	INCDRCA=9 INCDRCA=10	4	
			Decile 10	10				
			Not Applicable	96				
			Not Stated	99				

Table A.4 Construction of Lifestyle Confounders

Variable	Variable Name	Question	Responses	Code	Recoded categories	Recoded variables	Recoded value	Removed variables
PACDLTI	Leisure and transportation physical activity index	Derived variable based on PACDTLE (Daily energy. Expenditure: Transportation and leisure physical activity)	Active	1	Physically active	PACDLTI= 1		PACDLTI=9
			Moderately Active	2	Moderately physically active	PACDLTI= 2		
			Inactive	3	Physically inactive	PACDLTI= 3		
			Not stated	9				
SMKDSTY			Daily Smoker	1	Daily Smoker	SMKDSTY=1		

	Type of smoker	Derived variable based on SMK_01A (Smoked 100 or more cigarettes), SMK_01B (Ever smoked whole cigarette), SMK_202 (Type of smoker), SMK_05D (Ever smoked cigarettes daily)	Occasional Smoker (Formerly Daily Smoker)	2	Occasional Smoker	SMKDSTY=2 SMKDSTY=3		SMKDSTY=99
			Always An Occasional Smoker	3				
			Former Daily Smoker	4	Former Smoker	SMKDSTY=4 SMKDSTY=5		
			Former Occasional Smoker	5				
			Never Smoked	6	Never Smoker	SMKDSTY=6		
			Not Stated	99				
ALCDTTM	Type of drinker (12 months)	Derived variable based on ALC_1 (Drank alcohol in past 12 months), ALC_2 (Frequency of drinking alcohol).	Regular Drinker	1	Regular drinker	ALCDTTM=1		ALCDTTM=9
			Occasional Drinker	2	Occasional drinker	ALCDTTM=2		
			Did not Drink in the last 12 months	3	Nondrinker	ALCDTTM=3 ALCDTTM=9		
			Not Stated	9				

Appendix B: Gender Stratified Cross-Tabulations

Table B.1 Cross Tabulations of Population Based (per 10000 Individuals) Food Environment Densities by Chronic Disease Prevalence: Males

Disease Status	Mean (SD)					
	Supermarkets and Large Grocery Stores	Intermediate Grocery Stores	Small Grocery and Convenience Stores	Fast-food Restaurants	Full-service Restaurants	Local and Non-chain Restaurants
Type II Diabetes Prevalence						
No Diabetes	0.680 (0.612)	2.138 (1.677)	4.030 (2.900)	7.418 (5.010)	1.231 (1.370)	13.838 (12.708)
Diabetes	0.728 (0.599)	2.252 (1.799)	4.301 92.891)	7.764 (4.915)	1.246 (1.368)	13.605 (11.927)
Cardiovascular Disease Prevalence						
No Cardiovascular disease	0.679 (0.609)	2.144 (1.688)	4.032 (2.893)	7.446 (5.023)	1.236 (1.375)	13.806 (12.712)
Cardiovascular disease	0.764 (0.639)	2.230 (1.732)	4.355 (3.009)	7.512 (4.743)	1.181 (1.331)	13.927 (11.417)
Hypertension Prevalence						
No Hypertension	0.671 (0.605)	2.144 (1.691)	4.036 (2.917)	7.440 (5.060)	1.225 (1.352)	13.804 (12.731)
Hypertension	0.671 (0.605)	2.166 (1.688)	4.101 (2.834)	7.476 (4.796)	1.256 (1.436)	13.760 (12.101)

Table B.2 Cross Tabulations of Area Based (per km^2) Food Environment Densities by Chronic Disease Prevalence: Males

Disease Status	Mean (SD)					
	Supermarkets and Large Grocery Stores	Intermediate Grocery Stores	Small Grocery and Convenience Stores	Fast-food Restaurants	Full-service Restaurants	Local and Non-chain Restaurants
Type II Diabetes Prevalence						
No Diabetes	0.095 (0.143)	0.423 (0.752)	0.960 (1.772)	1.411 (2.103)	0.227 (0.430)	3.334 (7.700)
Diabetes	0.093 (0.127)	0.385 (0.625)	0.857 (1.423)	1.368 (2.035)	0.220 (0.485)	2.707 (5.992)
Cardiovascular Disease Prevalence						
No Cardiovascular disease	0.094 (0.141)	0.423 (0.743)	0.954 (1.753)	1.413 (2.100)	0.227 (0.433)	3.292 (7.570)
Cardiovascular disease	0.101 (0.147)	0.374 (0.713)	0.882 (1.583)	1.309 (2.073)	0.212 (0.474)	3.060 (7.448)
Hypertension Prevalence						
No Hypertension	0.096 (0.144)	0.435 (0.760)	0.981 (1.790)	1.449 (2.140)	0.234 (0.458)	3.278 (7.022)
Hypertension	0.089 (0.129)	0.360 (0.648)	0.834 (1.545)	1.255 (1.935)	0.197 (0.340)	3.234 (9.128)

Table B.3 Cross Tabulations of Population Based (per 10000 Individuals) Food Environment Densities by Chronic Disease Prevalence: Females

Disease Status	Mean (SD)					
	Supermarkets and Large Grocery Stores	Intermediate Grocery Stores	Small Grocery and Convenience Stores	Fast-food Restaurants	Full-service Restaurants	Local and Non-chain Restaurants
Type II Diabetes Prevalence						
No Diabetes	0.690 (0.617)	2.135 (1.649)	4.021 (2.911)	7.579 (5.036)	1.257 (1.384)	13.497 (12.094)
Diabetes	0.732 (0.599)	2.358 (1.757)	4.557 (3.109)	7.962 (4.845)	1.244 (1.358)	13.101 (9.973)
Cardiovascular Disease Prevalence						
No Cardiovascular disease	0.689 (0.614)	2.140 (1.652)	4.045 (2.927)	7.593 (5.032)	1.256 (1.386)	13.478 (12.033)
Cardiovascular disease	0.775 (0.659)	2.333 (1.704)	4.204 (2.864)	7.788 (4.873)	1.265 (1.320)	13.400 (10.561)
Hypertension Prevalence						
No Hypertension	0.683 (0.613)	2.123 (1.648)	4.019 (2.943)	7.620 (5.055)	1.262 (1.389)	13.550 (12.178)
Hypertension	0.724 (0.624)	2.240 (1.676)	4.175 (2.861)	7.528 (4.915)	1.234 (1.362)	13.194 (11.194)

Table B.4 Cross Tabulations of Area Based (per km^2) Food Environment Densities by Chronic Disease Prevalence: Females

Disease Status	Mean (SD)					
	Supermarkets and Large Grocery Stores	Intermediate Grocery Stores	Small Grocery and Convenience Stores	Fast-food Restaurants	Full-service Restaurants	Local and Non-chain Restaurants
Type II Diabetes Prevalence						
No Diabetes	0.094 (0.139)	0.405 (0.670)	0.940 (1.776)	1.448 (2.243)	0.236 (0.443)	3.100 (6.891)
Diabetes	0.108 (0.157)	0.454 (0.716)	1.056 (1.731)	1.502 (1.828)	0.228 (0.369)	2.864 (5.736)
Cardiovascular Disease Prevalence						
No Cardiovascular disease	0.095 (0.141)	0.409 (0.701)	0.950 (1.778)	1.458 (2.217)	0.237 (0.442)	3.115 (6.898)
Cardiovascular disease	0.085 (0.127)	0.380 (0.667)	0.834 (1.640)	1.277 (2.256)	0.204 (0.368)	2.385 (4.733)
Hypertension Prevalence						
No Hypertension	0.095 (0.141)	0.413 (0.717)	0.964 (1.824)	1.488 (2.295)	0.240 (0.453)	3.218 (7.166)
Hypertension	0.094 (0.136)	0.388 (0.634)	0.880 (1.573)	1.311 (1.897)	0.220 (0.381)	2.593 (5.332)

Appendix C: Gender Stratified Multivariate Analysis

Table C.1 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Type II Diabetes Prevalence and Population based (per 10000 individual) Food Environment Measures: Male

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.089 (0.970 - 1.222)	1.042 (0.919 - 1.182)	1.045 (0.920 - 1.187)
Intermediate Grocery Stores	1.049 (0.988 - 1.113)	1.013 (0.950 - 1.081)	1.015 (0.953 - 1.081)
Small Grocery and Convenience Stores	1.026** (1.002 - 1.051)	1.028* (0.996 - 1.061)	1.021 (0.989 - 1.053)
Fast-food Restaurants	1.019* (0.998 - 1.040)	1.015 (0.994 - 1.037)	1.013 (0.992 - 1.034)
Full-service Restaurants	0.99 (0.925 - 1.060)	1.008 (0.940 - 1.081)	1.016 (0.948 - 1.089)
Local and Non-chain Restaurants	0.986*** (0.976 - 0.997)	0.992 (0.981 - 1.003)	0.993 (0.982 - 1.005)
Individual Level Confounders			
Age			
Age	--	1.319*** (1.216 - 1.430)	1.294*** (1.193 - 1.404)
Age^2	--	0.998*** (0.997 - 0.999)	0.998*** (0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.790*** (1.223 - 2.620)	1.704*** (1.198 - 2.423)
Length of Residency: +10 years	--	1.164 (0.971 - 1.394)	1.205** (1.009 - 1.441)
Canadian born (ref)	--		
Marital Status			
Married	--	1.047 (0.840 - 1.305)	0.977 (0.784 - 1.218)
Widowed/Separated/ Divorced	--	0.853 (0.664 - 1.095)	0.849 (0.663 - 1.087)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.830** (0.690 - 0.999)	0.9 (0.747 - 1.084)
Incomplete Postsecondary Education	--	1.166 (0.882 - 1.541)	1.249 (0.941 - 1.657)
High School Diploma	--	1.04 (0.819 - 1.321)	1.124 (0.889 - 1.422)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.612*** (0.479 - 0.781)	0.695*** (0.542 - 0.892)
Quintile 4	--	0.730*** (0.584 - 0.912)	0.779** (0.616 - 0.984)
Quintile 3	--	0.676*** (0.542 - 0.843)	0.725*** (0.579 - 0.907)
Quintile 2	--	0.861 (0.688 - 1.077)	0.889 (0.719 - 1.100)
Quintile 1 (ref)	--	--	--

Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.007*** (1.003 - 1.011)	1.008*** (1.003 - 1.012)
Percentage of Low Income	--	1.003 (0.987 - 1.020)	1.004 (0.988 - 1.019)
Percentage of High School Education	--	1.010** (1.001 - 1.020)	1.005 (0.996 - 1.015)
Percentage of Driving to Work	--	1.004 (0.993 - 1.015)	1.002 (0.992 - 1.013)
Population Density	--	1 (1.000 - 1.000)	1 (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	3.263*** (2.610 - 4.080)
Overweight	--	--	1.446*** (1.147 - 1.821)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			0.964 (0.829 - 1.121)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.720*** (0.588 - 0.882)
Moderately Active	--	--	0.932 (0.786 - 1.105)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.595*** (0.498 - 0.711)
Occasionally Drinker	--	--	0.923 (0.759 - 1.121)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	0.883 (0.695 - 1.120)
Occasional Smoker	--	--	0.737 (0.441 - 1.231)
Former Smoker	--	--	0.965 (0.801 - 1.162)
Never Smoker (ref)	--	--	--

Table C.2 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Type II Diabetes Prevalence and Population based (per 10000 individual) Food Environment Measures: Female

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	0.999 (0.902 - 1.106)	0.974 (0.864 - 1.099)	0.987 (0.876 - 1.111)
Intermediate Grocery Stores	1.076**	1.063*	1.059*

	(1.017 - 1.138)	(0.998 - 1.132)	(0.997 - 1.125)
Small Grocery and Convenience Stores	1.060***	1.033	1.019
	(1.025 - 1.097)	(0.993 - 1.075)	(0.983 - 1.058)
Fast-food Restaurants	1.032***	1.039***	1.030***
	(1.012 - 1.051)	(1.019 - 1.059)	(1.009 - 1.051)
Full-service Restaurants	0.973	0.971	0.99
	(0.914 - 1.036)	(0.906 - 1.042)	(0.925 - 1.059)
Local and Non-chain Restaurants	0.980***	0.976***	0.979***
	(0.969 - 0.991)	(0.964 - 0.988)	(0.968 - 0.990)
Individual Level Confounders			
Age			
Age	--	1.330***	1.268***
		(1.210 - 1.463)	(1.157 - 1.391)
Age^2	--	0.998***	0.998***
		(0.997 - 0.999)	(0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.462	1.402
		(0.786 - 2.719)	(0.739 - 2.659)
Length of Residency: +10 years	--	1.313**	1.320***
		(1.062 - 1.623)	(1.070 - 1.628)
Canadian born (ref)	--		
Marital Status			
Married	--	0.559***	0.631***
		(0.412 - 0.758)	(0.471 - 0.845)
Widowed/Separated/ Divorced	--	0.619***	0.707**
		(0.457 - 0.837)	(0.530 - 0.941)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.680***	0.881
		(0.552 - 0.837)	(0.707 - 1.097)
Incomplete Postsecondary Education	--	0.633***	0.779
		(0.458 - 0.876)	(0.561 - 1.083)
High School Diploma	--	0.797*	0.892
		(0.628 - 1.011)	(0.704 - 1.128)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.599***	0.878
		(0.415 - 0.864)	(0.604 - 1.276)
Quintile 4	--	0.572***	0.770**
		(0.444 - 0.736)	(0.598 - 0.991)
Quintile 3	--	0.842	0.997
		(0.661 - 1.074)	(0.779 - 1.277)
Quintile 2	--	0.700***	0.785**
		(0.565 - 0.866)	(0.635 - 0.969)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.006**	1.004
		(1.001 - 1.012)	(0.998 - 1.009)
Percentage of Low Income	--	1.008	1.013
		(0.989 - 1.026)	(0.994 - 1.033)
Percentage of High School Education	--	1.019***	1.010**
		(1.008 - 1.030)	(1.000 - 1.021)
Percentage of Driving to Work	--	1.005	1.006
		(0.992 - 1.018)	(0.993 - 1.020)
Population Density	--	1	1
		(1.000 - 1.000)	(1.000 - 1.000)

Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	4.504*** (3.366 - 6.027)
Overweight	--	--	1.910*** (1.393 - 2.618)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			0.897 (0.755 - 1.065)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.682*** (0.538 - 0.865)
Moderately Active	--	--	0.790** (0.651 - 0.959)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.532*** (0.431 - 0.655)
Occasionally Drinker	--	--	0.893 (0.719 - 1.109)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	1.068 (0.834 - 1.369)
Occasional Smoker	--	--	0.835 (0.462 - 1.509)
Former Smoker	--	--	0.991 (0.845 - 1.162)
Never Smoker (ref)	--	--	--

Table C.3 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Cardiovascular Disease Prevalence and Population based (per 10000 individual) Food Environment Measures: Male

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.208*** (1.069 - 1.365)	1.119 (0.973 - 1.287)	1.122 (0.972 - 1.294)
Intermediate Grocery Stores	0.991 (0.933 - 1.052)	0.954 (0.892 - 1.021)	0.957 (0.895 - 1.023)
Small Grocery and Convenience Stores	1.032** (1.004 - 1.062)	1.037* (0.999 - 1.077)	1.032 (0.994 - 1.072)
Fast-food Restaurants	1.005 (0.980 - 1.030)	0.993 (0.968 - 1.019)	0.992 (0.966 - 1.019)
Full-service Restaurants	0.953 (0.886 - 1.025)	0.962 (0.890 - 1.040)	0.959 (0.886 - 1.038)
Local and Non-chain Restaurants	0.996 (0.986 - 1.006)	1 (0.989 - 1.012)	1.002 (0.991 - 1.014)
Individual Level Confounders			
Age			
Age	--	1.404*** (1.270 - 1.552)	1.374*** (1.242 - 1.520)

Age^2	--	0.998*** (0.997 - 0.999)	0.998*** (0.997 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	0.550* (0.270 - 1.120)	0.583 (0.295 - 1.149)
Length of Residency: +10 years	--	0.848 (0.644 - 1.117)	0.872 (0.656 - 1.160)
Canadian born (ref)	--		
Marital Status			
Married	--	1.19 (0.927 - 1.526)	1.141 (0.885 - 1.473)
Widowed/Separated/ Divorced	--	1.083 (0.845 - 1.387)	1.047 (0.817 - 1.343)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.8 (0.597 - 1.071)	0.864 (0.656 - 1.139)
Incomplete Postsecondary Education	--	0.911 (0.638 - 1.300)	0.969 (0.687 - 1.368)
High School Diploma	--	0.706** (0.505 - 0.989)	0.734* (0.525 - 1.026)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.748** (0.566 - 0.989)	0.791 (0.591 - 1.060)
Quintile 4	--	0.747** (0.570 - 0.979)	0.781* (0.590 - 1.035)
Quintile 3	--	0.939 (0.741 - 1.192)	0.942 (0.738 - 1.202)
Quintile 2	--	0.949 (0.704 - 1.278)	0.974 (0.715 - 1.326)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.003 (0.997 - 1.009)	1.004 (0.998 - 1.010)
Percentage of Low Income	--	0.997 (0.978 - 1.016)	0.996 (0.977 - 1.016)
Percentage of High School Education	--	1.007 (0.998 - 1.015)	1.004 (0.996 - 1.013)
Percentage of Driving to Work	--	0.990** (0.980 - 1.000)	0.989** (0.979 - 0.999)
Population Density	--	1.000** (1.000 - 1.000)	1.000** (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	1.720*** (1.377 - 2.148)
Overweight	--	--	1.352** (1.072 - 1.705)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			0.999 (0.848 - 1.177)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.785**

			(0.641 - 0.962)
Moderately Active	--	--	0.911 (0.751 - 1.106)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.848 (0.696 - 1.033)
Occasionally Drinker	--	--	1.015 (0.794 - 1.297)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	1.447** (1.041 - 2.011)
Occasional Smoker	--	--	1.112 (0.734 - 1.684)
Former Smoker	--	--	1.406*** (1.124 - 1.759)
Never Smoker (ref)	--	--	--

Table C.4 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Cardiovascular Disease Prevalence and Population based (per 10000 individual) Food Environment Measures: Female

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.135** (1.003 - 1.283)	1.011 (0.882 - 1.158)	1.01 (0.881 - 1.159)
Intermediate Grocery Stores	1.060** (1.005 - 1.117)	1.016 (0.962 - 1.073)	1.023 (0.968 - 1.080)
Small Grocery and Convenience Stores	1.026* (0.996 - 1.056)	0.997 (0.962 - 1.034)	0.992 (0.956 - 1.028)
Fast-food Restaurants	1.018 (0.996 - 1.041)	1.016 (0.993 - 1.040)	1.011 (0.987 - 1.035)
Full-service Restaurants	0.978 (0.906 - 1.057)	0.992 (0.914 - 1.076)	0.995 (0.915 - 1.083)
Local and Non-chain Restaurants	0.988** (0.978 - 0.998)	0.992 (0.980 - 1.003)	0.994 (0.983 - 1.006)
Individual Level Confounders			
Age			
Age	--	1.132** (1.013 - 1.265)	1.102* (0.983 - 1.234)
Age^2	--	1 (0.999 - 1.000)	1 (0.999 - 1.001)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.061 (0.451 - 2.493)	1.201 (0.499 - 2.891)
Length of Residency: +10 years	--	0.678*** (0.522 - 0.881)	0.735** (0.557 - 0.969)
Canadian born (ref)	--		
Marital Status			
Married	--	1.07 (0.739 - 1.550)	1.158 (0.783 - 1.713)
Widowed/Separated/ Divorced	--	1.226 (0.841 - 1.786)	1.272 (0.857 - 1.886)

Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.83 (0.661 - 1.042)	0.957 (0.758 - 1.208)
Incomplete Postsecondary Education	--	0.692** (0.504 - 0.950)	0.746* (0.537 - 1.038)
High School Diploma	--	0.946 (0.724 - 1.236)	1.021 (0.777 - 1.342)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.418*** (0.280 - 0.624)	0.521*** (0.348 - 0.781)
Quintile 4	--	0.495*** (0.353 - 0.693)	0.594*** (0.426 - 0.829)
Quintile 3	--	0.615*** (0.469 - 0.806)	0.677*** (0.514 - 0.891)
Quintile 2	--	0.786** (0.625 - 0.988)	0.84 (0.669 - 1.056)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	0.996 (0.989 - 1.003)	0.996 (0.989 - 1.003)
Percentage of Low Income	--	1.01 (0.990 - 1.029)	1.008 (0.990 - 1.027)
Percentage of High School Education	--	1.003 (0.991 - 1.016)	0.999 (0.987 - 1.012)
Percentage of Driving to Work	--	1.006 (0.991 - 1.020)	1.006 (0.992 - 1.021)
Population Density	--	1 0.996	1 0.996
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	1.576*** (1.244 - 1.997)
Overweight	--	--	1.269* (1.000 - 1.612)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			1.04 (0.871 - 1.243)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.754** (0.580 - 0.981)
Moderately Active	--	--	0.823 (0.651 - 1.039)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.682*** (0.528 - 0.881)
Occasionally Drinker	--	--	1.044 (0.828 - 1.315)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	1.742***

			(1.316 - 2.306)
Occasional Smoker	--	--	1.580* (0.982 - 2.542)
Former Smoker	--	--	1.345*** (1.079 - 1.676)
Never Smoker (ref)	--	--	--

Table C.5 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Hypertension Prevalence and Population based (per 10000 individual) Food Environment Measures: Male

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.106*** (1.036 - 1.181)	1.034 (0.959 - 1.114)	1.036 (0.958 - 1.120)
Intermediate Grocery Stores	1.003 (0.975 - 1.033)	0.976 (0.947 - 1.006)	0.981 (0.952 - 1.011)
Small Grocery and Convenience Stores	1.003 (0.987 - 1.020)	1.012 (0.991 - 1.033)	1.009 (0.988 - 1.029)
Fast-food Restaurants	0.997 (0.985 - 1.010)	0.992 (0.979 - 1.006)	0.993 (0.980 - 1.007)
Full-service Restaurants	1.016 (0.974 - 1.060)	1.017 (0.974 - 1.062)	1.013 (0.971 - 1.058)
Local and Non-chain Restaurants	0.996 (0.991 - 1.001)	1.003 (0.997 - 1.008)	1.004 (0.998 - 1.010)
Individual Level Confounders			
Age			
Age	--	1.215*** (1.159 - 1.274)	1.189*** (1.133 - 1.249)
Age^2	--	0.999*** (0.998 - 0.999)	0.999*** (0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.07 (0.771 - 1.485)	1.152 (0.832 - 1.597)
Length of Residency: +10 years	--	0.965 (0.852 - 1.094)	0.992 (0.876 - 1.124)
Canadian born (ref)	--		
Marital Status			
Married	--	1.048 (0.922 - 1.190)	0.994 (0.876 - 1.129)
Widowed/Separated/ Divorced	--	0.981 (0.851 - 1.130)	0.959 (0.834 - 1.104)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.827*** (0.723 - 0.946)	0.877** (0.770 - 0.999)
Incomplete Postsecondary Education	--	0.992 (0.826 - 1.191)	0.987 (0.822 - 1.185)
High School Diploma	--	0.865* (0.737 - 1.014)	0.901 (0.772 - 1.052)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.942 (0.810 - 1.096)	0.957 (0.819 - 1.118)

Quintile 4	--	0.896 (0.777 - 1.034)	0.885 (0.763 - 1.026)
Quintile 3	--	0.889 (0.764 - 1.035)	0.870* (0.745 - 1.015)
Quintile 2	--	1.02 (0.883 - 1.177)	1.039 (0.897 - 1.203)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.003* (1.000 - 1.006)	1.004** (1.001 - 1.006)
Percentage of Low Income	--	0.995 (0.985 - 1.005)	0.996 (0.986 - 1.006)
Percentage of High School Education	--	1.008** (1.001 - 1.015)	1.004 (0.998 - 1.011)
Percentage of Driving to Work	--	1.005 (0.998 - 1.012)	1.005 (0.998 - 1.012)
Population Density	--	1 (1.000 - 1.000)	1 (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	2.500*** (2.192 - 2.851)
Overweight	--	--	1.440*** (1.259 - 1.648)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			0.958 (0.871 - 1.053)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.784*** (0.701 - 0.877)
Moderately Active	--	--	0.918* (0.829 - 1.016)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.978 (0.877 - 1.091)
Occasionally Drinker	--	--	0.974 (0.840 - 1.129)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	1.006 (0.858 - 1.179)
Occasional Smoker	--	--	0.859 (0.671 - 1.100)
Former Smoker	--	--	0.958 (0.858 - 1.069)
Never Smoker (ref)	--	--	--

Table C.6 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Hypertension Prevalence and Population based (per 10000 individual) Food Environment Measures: Female

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals)		

*** p<0.01, ** p<0.05, * p<0.1

Density Measures			
Supermarkets and Large Grocery Stores	1.048 (0.988 - 1.112)	1.002 (0.944 - 1.064)	1.019 (0.961 - 1.080)
Intermediate Grocery Stores	1.032** (1.006 - 1.059)	1.023* (0.996 - 1.050)	1.022* (0.997 - 1.047)
Small Grocery and Convenience Stores	1.022*** (1.005 - 1.040)	1.012 (0.994 - 1.031)	1.008 (0.991 - 1.026)
Fast-food Restaurants	1.003 (0.991 - 1.015)	0.999 (0.988 - 1.010)	0.994 (0.983 - 1.005)
Full-service Restaurants	1.002 (0.963 - 1.043)	1.006 (0.966 - 1.047)	1.018 (0.978 - 1.060)
Local and Non-chain Restaurants	0.991*** (0.986 - 0.996)	0.995* (0.989 - 1.000)	0.996 (0.991 - 1.002)
Individual Level Confounders			
Age			
Age	--	1.220*** (1.155 - 1.289)	1.182*** (1.122 - 1.246)
Age^2	--	0.999*** (0.998 - 0.999)	0.999*** (0.999 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.255 (0.897 - 1.755)	1.293 (0.928 - 1.802)
Length of Residency: +10 years	--	1.079 (0.967 - 1.204)	1.085 (0.969 - 1.214)
Canadian born (ref)	--		
Marital Status			
Married	--	0.862* (0.734 - 1.012)	0.897 (0.770 - 1.045)
Widowed/Separated/ Divorced	--	0.875 (0.743 - 1.031)	0.926 (0.790 - 1.085)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.808*** (0.722 - 0.905)	0.909 (0.808 - 1.022)
Incomplete Postsecondary Education	--	0.851* (0.715 - 1.013)	0.922 (0.776 - 1.094)
High School Diploma	--	0.912 (0.805 - 1.034)	0.966 (0.849 - 1.099)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.728*** (0.607 - 0.874)	0.834* (0.692 - 1.005)
Quintile 4	--	0.800*** (0.686 - 0.933)	0.886 (0.758 - 1.036)
Quintile 3	--	0.793*** (0.703 - 0.894)	0.830*** (0.734 - 0.938)
Quintile 2	--	0.858*** (0.768 - 0.958)	0.892** (0.798 - 0.998)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.002* (1.000 - 1.005)	1.002 (0.999 - 1.004)
Percentage of Low Income	--	0.996 (0.987 - 1.005)	0.998 (0.989 - 1.007)
Percentage of High School Education	--	1.007**	1.003

		(1.001 - 1.013)	(0.997 - 1.008)
Percentage of Driving to Work	--	1.004	1.004
		(0.998 - 1.010)	(0.998 - 1.010)
Population Density	--	1	1
		(1.000 - 1.000)	(1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	2.555***
			(2.261 - 2.887)
Overweight	--	--	1.723***
			(1.519 - 1.954)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			0.933
			(0.857 - 1.015)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.796***
			(0.713 - 0.889)
Moderately Active	--	--	1.02
			(0.926 - 1.125)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.881**
			(0.789 - 0.983)
Occasionally Drinker	--	--	0.976
			(0.867 - 1.099)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	0.993
			(0.868 - 1.136)
Occasional Smoker	--	--	0.847
			(0.685 - 1.049)
Former Smoker	--	--	0.936
			(0.850 - 1.031)
Never Smoker (ref)	--	--	--

Table C.7 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Type II Diabetes Prevalence and Area based (per km^2) Food Environment Measures: Male

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.666	1.269	1.336
	(0.866 - 3.206)	(0.564 - 2.854)	(0.584 - 3.053)
Intermediate Grocery Stores	1.089	1.032	1.086
	(0.855 - 1.387)	(0.782 - 1.361)	(0.816 - 1.445)
Small Grocery and Convenience Stores	0.966	1.004	0.985
	(0.890 - 1.049)	(0.907 - 1.110)	(0.890 - 1.091)
Fast-food Restaurants	1.035	1.082*	1.089**
	(0.949 - 1.128)	(0.997 - 1.174)	(1.004 - 1.181)
Full-service Restaurants	0.913	0.925	0.911
	(0.645 - 1.292)	(0.649 - 1.318)	(0.641 - 1.294)
Local and Non-chain Restaurants	0.974	0.983	0.981

	(0.933 - 1.016)	(0.948 - 1.020)	(0.944 - 1.019)
Individual Level Confounders			
Age			
Age	--	1.330***	1.310***
		(1.225 - 1.446)	(1.205 - 1.423)
Age^2	--	0.998***	0.998***
		(0.997 - 0.999)	(0.997 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.787***	1.719***
		(1.212 - 2.635)	(1.205 - 2.454)
Length of Residency: +10 years	--	1.171*	1.209**
		(0.979 - 1.400)	(1.015 - 1.440)
Canadian born (ref)	--		
Marital Status			
Married	--	1.072	0.998
		(0.861 - 1.334)	(0.803 - 1.239)
Widowed/Separated/ Divorced	--	0.891	0.884
		(0.691 - 1.148)	(0.688 - 1.136)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.821**	0.892
		(0.684 - 0.987)	(0.741 - 1.073)
Incomplete Postsecondary Education	--	1.146	1.226
		(0.865 - 1.518)	(0.922 - 1.631)
High School Diploma	--	1.031	1.124
		(0.812 - 1.309)	(0.890 - 1.419)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.611***	0.697***
		(0.479 - 0.781)	(0.544 - 0.894)
Quintile 4	--	0.722***	0.776**
		(0.578 - 0.903)	(0.614 - 0.980)
Quintile 3	--	0.686***	0.740***
		(0.550 - 0.855)	(0.592 - 0.924)
Quintile 2	--	0.841	0.868
		(0.671 - 1.053)	(0.702 - 1.073)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.006***	1.007***
		(1.002 - 1.011)	(1.003 - 1.011)
Percentage of Low Income	--	1.002	1.001
		(0.986 - 1.019)	(0.986 - 1.017)
Percentage of High School Education	--	1.015***	1.010**
		(1.005 - 1.024)	(1.000 - 1.019)
Percentage of Driving to Work	--	1.003	1.002
		(0.992 - 1.015)	(0.991 - 1.013)
Population Density	--	1	1
		(1.000 - 1.000)	(1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	3.261***
			(2.611 - 4.072)
Overweight	--	--	1.397***
			(1.112 - 1.755)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			

5 or More Daily Servings			0.992 (0.854 - 1.153)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.706*** (0.577 - 0.863)
Moderately Active	--	--	0.929 (0.783 - 1.103)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.596*** (0.499 - 0.712)
Occasionally Drinker	--	--	0.928 (0.763 - 1.128)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	0.884 (0.696 - 1.123)
Occasional Smoker	--	--	0.753 (0.450 - 1.259)
Former Smoker	--	--	0.965 (0.803 - 1.160)
Never Smoker (ref)	--	--	--

Table C.9 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Type II Diabetes Prevalence and Area based (per km^2) Food Environment Measures: Female

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.755 (0.703 - 4.382)	1.844 (0.592 - 5.751)	2.127 (0.686 - 6.594)
Intermediate Grocery Stores	1.225** (1.003 - 1.498)	1.143 (0.902 - 1.448)	1.153 (0.904 - 1.471)
Small Grocery and Convenience Stores	1.004 (0.924 - 1.090)	1.076 (0.964 - 1.200)	1.026 (0.922 - 1.141)
Fast-food Restaurants	1.082* (0.988 - 1.185)	1.098* (0.999 - 1.206)	1.081 (0.981 - 1.191)
Full-service Restaurants	0.997 (0.720 - 1.380)	0.958 (0.664 - 1.384)	0.993 (0.693 - 1.423)
Local and Non-chain Restaurants	0.942** (0.898 - 0.988)	0.950* (0.900 - 1.003)	0.956* (0.912 - 1.003)
Individual Level Confounders			
Age			
Age	--	1.329*** (1.209 - 1.462)	1.269*** (1.156 - 1.393)
Age^2	--	0.998*** (0.997 - 0.999)	0.998*** (0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.472 (0.795 - 2.727)	1.448 (0.776 - 2.700)
Length of Residency: +10 years	--	1.303** (1.053 - 1.614)	1.308** (1.060 - 1.614)
Canadian born (ref)	--		

Marital Status			
Married	--	0.556*** (0.411 - 0.751)	0.630*** (0.472 - 0.840)
Widowed/Separated/ Divorced	--	0.615*** (0.457 - 0.828)	0.711** (0.536 - 0.943)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.686*** (0.558 - 0.843)	0.885 (0.710 - 1.102)
Incomplete Postsecondary Education	--	0.626*** (0.451 - 0.868)	0.769 (0.551 - 1.073)
High School Diploma	--	0.798* (0.630 - 1.011)	0.885 (0.699 - 1.122)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.591*** (0.408 - 0.856)	0.869 (0.596 - 1.267)
Quintile 4	--	0.568*** (0.440 - 0.732)	0.765** (0.592 - 0.988)
Quintile 3	--	0.836 (0.657 - 1.065)	0.995 (0.777 - 1.274)
Quintile 2	--	0.696*** (0.562 - 0.862)	0.781** (0.632 - 0.966)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.006** (1.001 - 1.012)	1.003 (0.997 - 1.009)
Percentage of Low Income	--	1.009 (0.992 - 1.027)	1.014 (0.996 - 1.032)
Percentage of High School Education	--	1.021*** (1.010 - 1.031)	1.012** (1.002 - 1.022)
Percentage of Driving to Work	--	1.006 (0.993 - 1.020)	1.008 (0.994 - 1.022)
Population Density	--	1 (1.000 - 1.000)	1 (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	4.582*** (3.422 - 6.134)
Overweight	--	--	1.912*** (1.398 - 2.616)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			0.908 (0.765 - 1.078)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.705*** (0.557 - 0.892)
Moderately Active	--	--	0.791** (0.650 - 0.963)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.526*** (0.428 - 0.647)

Occasionally Drinker	--	--	0.874 (0.707 - 1.080)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	1.046 (0.817 - 1.340)
Occasional Smoker	--	--	0.799 (0.441 - 1.448)
Former Smoker	--	--	0.98 (0.836 - 1.149)
Never Smoker (ref)	--	--	--

Table C.10 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Cardiovascular Disease Prevalence and Area based (per km^2) Food Environment Measures: Male

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	2.268 (0.556 - 9.240)	2.498 (0.611 - 10.202)	2.445 (0.593 - 10.076)
Intermediate Grocery Stores	0.750** (0.582 - 0.967)	0.653** (0.466 - 0.915)	0.671** (0.476 - 0.946)
Small Grocery and Convenience Stores	1.065 (0.964 - 1.176)	1.087 (0.963 - 1.227)	1.075 (0.948 - 1.218)
Fast-food Restaurants	0.971 (0.870 - 1.084)	0.961 (0.852 - 1.084)	0.963 (0.852 - 1.088)
Full-service Restaurants	0.941 (0.653 - 1.357)	0.95 (0.649 - 1.388)	0.936 (0.632 - 1.385)
Local and Non-chain Restaurants	1.001 (0.970 - 1.034)	1.015 (0.979 - 1.052)	1.016 (0.980 - 1.053)
Individual Level Confounders			
Age			
Age	--	1.427*** (1.290 - 1.578)	1.395*** (1.261 - 1.543)
Age^2	--	0.998*** (0.997 - 0.999)	0.998*** (0.997 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	0.562 (0.278 - 1.136)	0.591 (0.301 - 1.159)
Length of Residency: +10 years	--	0.827 (0.632 - 1.082)	0.853 (0.646 - 1.126)
Canadian born (ref)	--		
Marital Status			
Married	--	1.183 (0.928 - 1.508)	1.134 (0.885 - 1.452)
Widowed/Separated/ Divorced	--	1.073 (0.835 - 1.380)	1.038 (0.806 - 1.337)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.81 (0.615 - 1.067)	0.873 (0.671 - 1.137)
Incomplete Postsecondary Education	--	0.933 (0.665 - 1.308)	0.991 (0.714 - 1.377)

High School Diploma	--	0.720** (0.521 - 0.994)	0.747* (0.539 - 1.033)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.726** (0.550 - 0.959)	0.772* (0.576 - 1.034)
Quintile 4	--	0.736** (0.561 - 0.966)	0.775* (0.585 - 1.028)
Quintile 3	--	0.918 (0.725 - 1.162)	0.927 (0.729 - 1.179)
Quintile 2	--	0.928 (0.694 - 1.241)	0.957 (0.710 - 1.290)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.002 (0.996 - 1.008)	1.003 (0.998 - 1.009)
Percentage of Low Income	--	1.003 (0.986 - 1.021)	1.003 (0.985 - 1.020)
Percentage of High School Education	--	1.010** (1.001 - 1.018)	1.006 (0.998 - 1.015)
Percentage of Driving to Work	--	0.990** (0.980 - 1.000)	0.989** (0.979 - 0.999)
Population Density	--	1 (1.000 - 1.000)	1 (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	1.714*** (1.375 - 2.138)
Overweight	--	--	1.335** (1.065 - 1.674)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			1.002 (0.851 - 1.181)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.796** (0.650 - 0.974)
Moderately Active	--	--	0.922 (0.759 - 1.121)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.827* (0.683 - 1.000)
Occasionally Drinker	--	--	1.004 (0.788 - 1.280)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	1.451** (1.059 - 1.989)
Occasional Smoker	--	--	1.107 (0.727 - 1.688)
Former Smoker	--	--	1.398*** (1.116 - 1.752)
Never Smoker (ref)	--	--	--

Table C.11 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Cardiovascular Disease Prevalence and Area based (per km^2) Food Environment Measures: Female

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	0.683 (0.252 - 1.851)	0.456 (0.137 - 1.522)	0.528 (0.156 - 1.792)
Intermediate Grocery Stores	1.21 (0.908 - 1.614)	1.168 (0.804 - 1.698)	1.262 (0.872 - 1.826)
Small Grocery and Convenience Stores	1.032 (0.919 - 1.160)	1.004 (0.862 - 1.168)	0.962 (0.826 - 1.121)
Fast-food Restaurants	0.918 (0.806 - 1.047)	0.953 (0.835 - 1.088)	0.938 (0.823 - 1.069)
Full-service Restaurants	1.121 (0.764 - 1.645)	1.25 (0.856 - 1.826)	1.179 (0.791 - 1.757)
Local and Non-chain Restaurants	0.974 (0.929 - 1.020)	0.97 (0.923 - 1.019)	0.979 (0.935 - 1.024)
Individual Level Confounders			
Age			
Age	--	1.129** (1.011 - 1.260)	1.100* (0.983 - 1.230)
Age^2	--	1 (0.999 - 1.001)	1 (0.999 - 1.001)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.071 (0.457 - 2.510)	1.222 (0.510 - 2.928)
Length of Residency: +10 years	--	0.677*** (0.521 - 0.881)	0.735** (0.557 - 0.970)
Canadian born (ref)	--		
Marital Status			
Married	--	1.06 (0.733 - 1.534)	1.142 (0.773 - 1.686)
Widowed/Separated/ Divorced	--	1.202 (0.824 - 1.753)	1.241 (0.835 - 1.844)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.844 (0.673 - 1.060)	0.974 (0.772 - 1.229)
Incomplete Postsecondary Education	--	0.688** (0.499 - 0.948)	0.741* (0.531 - 1.035)
High School Diploma	--	0.977 (0.749 - 1.274)	1.052 (0.802 - 1.381)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.421*** (0.281 - 0.630)	0.526*** (0.350 - 0.789)
Quintile 4	--	0.492*** (0.352 - 0.688)	0.591*** (0.425 - 0.822)
Quintile 3	--	0.614*** (0.469 - 0.805)	0.677*** (0.515 - 0.889)
Quintile 2	--	0.774** (0.615 - 0.973)	0.829 (0.660 - 1.041)
Quintile 1 (ref)	--	--	--

Neighbourhood Level Covariates			
Percentage of Visual Minority	--	0.996 (0.989 - 1.002)	0.995 (0.989 - 1.002)
Percentage of Low Income	--	1.014 (0.994 - 1.033)	1.012 (0.993 - 1.031)
Percentage of High School Education	--	1.001 (0.989 - 1.013)	0.997 (0.985 - 1.009)
Percentage of Driving to Work	--	1.005 (0.990 - 1.021)	1.006 (0.990 - 1.022)
Population Density	--	1 (1.000 - 1.000)	1 (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	1.568*** (1.237 - 1.987)
Overweight	--	--	1.261* (0.993 - 1.600)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			1.036 (0.867 - 1.238)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.750** (0.577 - 0.976)
Moderately Active	--	--	0.827 (0.657 - 1.041)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.680*** (0.526 - 0.880)
Occasionally Drinker	--	--	1.031 (0.818 - 1.299)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	1.761*** (1.331 - 2.332)
Occasional Smoker	--	--	1.565* (0.977 - 2.507)
Former Smoker	--	--	1.343*** (1.077 - 1.675)
Never Smoker (ref)	--	--	--

Table C.12 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Hypertension Prevalence and Area based (per km^2) Food Environment Measures: Male

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.319 (0.793 - 2.194)	1.119 (0.662 - 1.892)	1.094 (0.640 - 1.870)
Intermediate Grocery Stores	0.916 (0.801 - 1.048)	0.816** (0.696 - 0.956)	0.863* (0.735 - 1.013)
Small Grocery and Convenience Stores	0.995	1.042	1.029

	(0.941 - 1.051)	(0.973 - 1.116)	(0.962 - 1.100)
Fast-food Restaurants	0.956	0.961	0.967
	(0.904 - 1.011)	(0.906 - 1.019)	(0.912 - 1.025)
Full-service Restaurants	0.979	1.006	1.017
	(0.795 - 1.207)	(0.819 - 1.237)	(0.832 - 1.244)
Local and Non-chain Restaurants	1.006	1.024***	1.024***
	(0.989 - 1.024)	(1.006 - 1.041)	(1.006 - 1.042)
Individual Level Confounders			
Age			
Age	--	1.215***	1.189***
		(1.159 - 1.274)	(1.133 - 1.248)
Age^2	--	0.999***	0.999***
		(0.998 - 0.999)	(0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.039	1.116
		(0.746 - 1.447)	(0.802 - 1.552)
Length of Residency: +10 years	--	0.962	0.99
		(0.849 - 1.088)	(0.876 - 1.119)
Canadian born (ref)	--		
Marital Status			
Married	--	1.047	0.991
		(0.923 - 1.187)	(0.875 - 1.122)
Widowed/Separated/ Divorced	--	0.972	0.947
		(0.844 - 1.119)	(0.823 - 1.089)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.823***	0.871**
		(0.721 - 0.939)	(0.766 - 0.990)
Incomplete Postsecondary Education	--	0.988	0.979
		(0.825 - 1.183)	(0.817 - 1.172)
High School Diploma	--	0.867*	0.905
		(0.741 - 1.014)	(0.779 - 1.053)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.942	0.955
		(0.810 - 1.096)	(0.817 - 1.116)
Quintile 4	--	0.891	0.878*
		(0.772 - 1.028)	(0.758 - 1.017)
Quintile 3	--	0.895	0.875*
		(0.770 - 1.042)	(0.751 - 1.019)
Quintile 2	--	1.016	1.032
		(0.881 - 1.171)	(0.894 - 1.192)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.003*	1.004**
		(1.000 - 1.006)	(1.001 - 1.007)
Percentage of Low Income	--	0.997	0.998
		(0.988 - 1.006)	(0.989 - 1.007)
Percentage of High School Education	--	1.009***	1.005*
		(1.002 - 1.015)	(0.999 - 1.011)
Percentage of Driving to Work	--	1.006	1.006*
		(0.999 - 1.013)	(0.999 - 1.013)
Population Density	--	1	1
		(1.000 - 1.000)	(1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			

Obese	--	--	2.548*** (2.237 - 2.903)
Overweight	--	--	1.465*** (1.283 - 1.673)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			0.959 (0.873 - 1.055)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.781*** (0.699 - 0.872)
Moderately Active	--	--	0.919 (0.830 - 1.017)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.988 (0.888 - 1.099)
Occasionally Drinker	--	--	0.985 (0.851 - 1.139)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	1.027 (0.878 - 1.202)
Occasional Smoker	--	--	0.871 (0.681 - 1.113)
Former Smoker	--	--	0.969 (0.867 - 1.082)
Never Smoker (ref)	--	--	--

Table C.13 Unadjusted and Adjusted Prevalence Ratios (95% CI) for Hypertension Prevalence and Area based (per km^2) Food Environment Measures: Female

Variables	Model 1	Model 2	Model 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.115 (0.754 - 1.649)	1.088 (0.702 - 1.687)	1.242 (0.803 - 1.920)
Intermediate Grocery Stores	1.077 (0.951 - 1.219)	1.1 (0.959 - 1.262)	1.107 (0.969 - 1.265)
Small Grocery and Convenience Stores	1.03 (0.974 - 1.088)	1.013 (0.951 - 1.078)	1.006 (0.946 - 1.070)
Fast-food Restaurants	0.977 (0.914 - 1.045)	0.946* (0.894 - 1.001)	0.936** (0.884 - 0.991)
Full-service Restaurants	1.185 (0.952 - 1.474)	1.191 (0.964 - 1.471)	1.240** (1.002 - 1.535)
Local and Non-chain Restaurants	0.969*** (0.948 - 0.992)	0.986 (0.966 - 1.007)	0.987 (0.967 - 1.007)
Individual Level Confounders			
Age			
Age	--	1.219*** (1.154 - 1.289)	1.182*** (1.121 - 1.246)
Age^2	--	0.999*** (0.998 - 0.999)	0.999*** (0.999 - 0.999)

Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	--	1.251 (0.888 - 1.762)	1.293 (0.920 - 1.817)
Length of Residency: +10 years	--	1.09 (0.978 - 1.214)	1.094 (0.979 - 1.222)
Canadian born (ref)	--		
Marital Status			
Married	--	0.859* (0.730 - 1.010)	0.889 (0.762 - 1.036)
Widowed/Separated/ Divorced	--	0.869* (0.736 - 1.026)	0.914 (0.779 - 1.073)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	--	0.811*** (0.725 - 0.908)	0.91 (0.809 - 1.024)
Incomplete Postsecondary Education	--	0.850* (0.714 - 1.013)	0.919 (0.773 - 1.092)
High School Diploma	--	0.913 (0.805 - 1.035)	0.966 (0.849 - 1.099)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	--	0.727*** (0.605 - 0.873)	0.834* (0.691 - 1.005)
Quintile 4	--	0.795*** (0.682 - 0.928)	0.88 (0.753 - 1.029)
Quintile 3	--	0.782*** (0.693 - 0.882)	0.821*** (0.726 - 0.928)
Quintile 2	--	0.849*** (0.760 - 0.949)	0.884** (0.790 - 0.989)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	--	1.002 (0.999 - 1.005)	1.001 (0.998 - 1.004)
Percentage of Low Income	--	0.995 (0.987 - 1.003)	0.997 (0.989 - 1.005)
Percentage of High School Education	--	1.008*** (1.003 - 1.014)	1.004 (0.999 - 1.009)
Percentage of Driving to Work	--	1.003 (0.997 - 1.009)	1.003 (0.997 - 1.009)
Population Density	--	1 (1.000 - 1.000)	1 (1.000 - 1.000)
Lifestyle Confounder and Mediators			
Weight Class			
Obese	--	--	2.552*** (2.257 - 2.885)
Overweight	--	--	1.724*** (1.520 - 1.955)
Under and Normal Weight (ref)	--	--	--
Fruits & vegetables Consumption			
5 or More Daily Servings			0.939 (0.863 - 1.021)
Less than 5 Daily Servings (ref)	--	--	--
Physical Activity Level			
Physically Active	--	--	0.797*** (0.714 - 0.889)

Moderately Active	--	--	1.02 (0.925 - 1.123)
Inactive (ref)	--	--	--
Type of Drinker			
Regular Drinker	--	--	0.877** (0.786 - 0.979)
Occasionally Drinker	--	--	0.973 (0.864 - 1.095)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	--	--	0.996 (0.871 - 1.139)
Occasional Smoker	--	--	0.845 (0.683 - 1.045)
Former Smoker	--	--	0.935 (0.849 - 1.030)
Never Smoker (ref)	--	--	--

Appendix D: Baron and Kenny Regression Tables: Obesity

Table D.1 Obesity Baron and Kenny Mediation Analysis: Type II Diabetes -- Overall

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.018 (0.931 - 1.114)	1.032*** (1.013 - 1.051)	1.018 (0.931 - 1.114)
Intermediate Grocery Stores	1.032 (0.986 - 1.080)	1.014*** (1.006 - 1.021)	1.037 (0.991 - 1.085)
Small Grocery and Convenience Stores	1.029** (1.003 - 1.056)	1.001 (0.995 - 1.006)	1.022* (0.998 - 1.048)
Fast-food Restaurants	1.020** (1.005 - 1.035)	1.005*** (1.001 - 1.009)	1.019** (1.004 - 1.035)
Full-service Restaurants	1.011 (0.960 - 1.064)	0.99 (0.978 - 1.003)	1.011 (0.962 - 1.062)
Local and Non-chain Restaurants	0.984*** (0.975 - 0.994)	0.994*** (0.993 - 0.996)	0.987*** (0.978 - 0.995)
Mediator			
Weight Class			
Obese	--	--	3.974*** (3.330 - 4.742)
Overweight	--	--	1.672*** (1.385 - 2.019)
Under and Normal Weight (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.330*** (1.249 - 1.417)	--	1.287*** (1.210 - 1.368)
Age^2	0.998*** (0.997 - 0.999)	--	0.998*** (0.998 - 0.999)
Gender			
Female	0.572*** (0.510 - 0.643)	--	0.598*** (0.533 - 0.670)
Male (ref)	--	--	--
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.422** (1.026 - 1.969)	--	1.663*** (1.220 - 2.267)
Length of Residency: +10 years	1.172** (1.015 - 1.353)	--	1.264*** (1.100 - 1.453)
Canadian born (ref)	--	--	--
Marital Status			
Married	0.813* (0.659 - 1.003)	--	0.804** (0.667 - 0.969)
Widowed/Separated/ Divorced	0.781** (0.627 - 0.974)	--	0.781** (0.642 - 0.951)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.791*** (0.689 - 0.908)	--	0.870* (0.757 - 1.000)
Incomplete Postsecondary Education	0.962 (0.775 - 1.194)	--	1.027 (0.828 - 1.274)
High School Diploma	0.955 (0.802 - 1.139)	--	1.009 (0.852 - 1.195)

Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.722***	--	0.734***
	(0.586 - 0.891)		(0.597 - 0.903)
Quintile 4	0.767***	--	0.769***
	(0.643 - 0.916)		(0.645 - 0.916)
Quintile 3	0.824**	--	0.814**
	(0.695 - 0.978)		(0.687 - 0.965)
Quintile 2	0.833**	--	0.839**
	(0.709 - 0.979)		(0.719 - 0.979)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.005***	--	1.007***
	(1.002 - 1.009)		(1.003 - 1.010)
Percentage of Low Income	1.007	--	1.007
	(0.994 - 1.019)		(0.995 - 1.020)
Percentage of High School Education	1.012***	--	1.008**
	(1.005 - 1.019)		(1.001 - 1.015)
Percentage of Driving to Work	1.003	--	1.005
	(0.995 - 1.012)		(0.996 - 1.013)
Population Density	1	--	1
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.532***	--	0.554***
	(0.463 - 0.611)		(0.483 - 0.635)
Occasionally Drinker	0.982	--	0.92
	(0.841 - 1.147)		(0.794 - 1.065)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.886	--	0.991
	(0.740 - 1.062)		(0.834 - 1.177)
Occasional Smoker	0.746	--	0.796
	(0.502 - 1.109)		(0.532 - 1.192)
Former Smoker	1.029	--	0.983
	(0.900 - 1.176)		(0.863 - 1.120)
Never Smoker (ref)	--	--	--

Table D.2 Obesity Baron and Kenny Mediation Analysis: Cardiovascular Disease -- Overall

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.081	1.032***	1.08
	(0.974 - 1.199)	(1.013 - 1.051)	(0.973 - 1.198)
Intermediate Grocery Stores	0.981	1.014***	0.983
	(0.936 - 1.029)	(1.006 - 1.021)	(0.938 - 1.031)
Small Grocery and Convenience Stores	1.017	1.001	1.017
	(0.989 - 1.046)	(0.995 - 1.006)	(0.989 - 1.045)
Fast-food Restaurants	0.999	1.005***	0.999
	(0.980 - 1.019)	(1.001 - 1.009)	(0.980 - 1.018)
Full-service Restaurants	0.976	0.99	0.978
	(0.920 - 1.034)	(0.978 - 1.003)	(0.923 - 1.037)
Local and Non-chain Restaurants	0.998	0.994***	0.998
	(0.989 - 1.006)	(0.993 - 0.996)	(0.990 - 1.007)

Mediator			
Weight Class			
Obese	--	--	1.720*** (1.463 - 2.023)
Overweight	--	--	1.325*** (1.117 - 1.572)
Under and Normal Weight (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.265*** (1.170 - 1.368)	--	1.248*** (1.154 - 1.350)
Age^2	0.999*** (0.998 - 0.999)	--	0.999*** (0.998 - 0.999)
Gender			
Female	0.542*** (0.481 - 0.611)	--	0.561*** (0.497 - 0.632)
Male (ref)	--	--	--
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	0.732 (0.428 - 1.252)	--	0.771 (0.450 - 1.320)
Length of Residency: +10 years	0.823* (0.657 - 1.030)	--	0.843 (0.675 - 1.051)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.186 (0.954 - 1.474)	--	1.167 (0.941 - 1.449)
Widowed/Separated/ Divorced	1.195 (0.961 - 1.486)	--	1.185 (0.954 - 1.472)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.85 (0.692 - 1.044)	--	0.878 (0.714 - 1.079)
Incomplete Postsecondary Education	0.855 (0.659 - 1.108)	--	0.87 (0.671 - 1.127)
High School Diploma	0.812* (0.641 - 1.029)	--	0.827 (0.652 - 1.048)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.687*** (0.547 - 0.864)	--	0.692*** (0.551 - 0.870)
Quintile 4	0.693*** (0.560 - 0.858)	--	0.695*** (0.562 - 0.859)
Quintile 3	0.820** (0.683 - 0.984)	--	0.818** (0.681 - 0.983)
Quintile 2	0.895 (0.727 - 1.103)	--	0.9 (0.732 - 1.108)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.001 (0.997 - 1.006)	--	1.001 (0.997 - 1.006)
Percentage of Low Income	1.001 (0.987 - 1.015)	--	1.001 (0.987 - 1.015)
Percentage of High School Education	1.004 (0.997 - 1.012)	--	1.003 (0.995 - 1.010)
Percentage of Driving to Work	0.995	--	0.995

	(0.987 - 1.003)		(0.987 - 1.004)
Population Density	1.000*	--	1.000*
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.755***	--	0.767***
	(0.643 - 0.885)		(0.655 - 0.898)
Occasionally Drinker	1.062	--	1.039
	(0.897 - 1.257)		(0.878 - 1.230)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	1.522***	--	1.601***
	(1.203 - 1.927)		(1.265 - 2.026)
Occasional Smoker	1.273	--	1.291
	(0.930 - 1.741)		(0.945 - 1.763)
Former Smoker	1.431***	--	1.408***
	(1.222 - 1.676)		(1.203 - 1.647)
Never Smoker (ref)	--	--	--

Table D.3 Obesity Baron and Kenny Mediation Analysis: Hypertension -- Overall

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.024	1.032***	1.027
	(0.975 - 1.076)	(1.013 - 1.051)	(0.978 - 1.079)
Intermediate Grocery Stores	0.998	1.014***	1.001
	(0.978 - 1.019)	(1.006 - 1.021)	(0.982 - 1.021)
Small Grocery and Convenience Stores	1.013*	1.001	1.01
	(0.998 - 1.027)	(0.995 - 1.006)	(0.996 - 1.024)
Fast-food Restaurants	0.994	1.005***	0.994
	(0.985 - 1.003)	(1.001 - 1.009)	(0.985 - 1.002)
Full-service Restaurants	1.016	0.99	1.018
	(0.986 - 1.048)	(0.978 - 1.003)	(0.988 - 1.048)
Local and Non-chain Restaurants	0.999	0.994***	1
	(0.995 - 1.003)	(0.993 - 0.996)	(0.996 - 1.004)
Mediator			
Weight Class			
Obese	--	--	2.672***
			(2.443 - 2.921)
Overweight	--	--	1.617***
			(1.474 - 1.775)
Under and Normal Weight (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.207***	--	1.181***
	(1.164 - 1.252)		(1.140 - 1.224)
Age^2	0.999***	--	0.999***
	(0.999 - 0.999)		(0.999 - 0.999)
Gender			
Female	0.876***	--	0.943*
	(0.823 - 0.932)		(0.886 - 1.003)
Male (ref)	--	--	--
Immigration Status/Length of Residency			

Length of Residency: 1 to 10 years	1.087 (0.850 - 1.390)	--	1.214 (0.960 - 1.536)
Length of Residency: +10 years	0.987 (0.901 - 1.080)	--	1.037 (0.950 - 1.131)
Canadian born (ref)	--	--	--
Marital Status			
Married	0.948 (0.851 - 1.056)	--	0.937 (0.847 - 1.037)
Widowed/Separated/ Divorced	0.956 (0.851 - 1.073)	--	0.955 (0.857 - 1.065)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.817*** (0.747 - 0.894)	--	0.870*** (0.796 - 0.951)
Incomplete Postsecondary Education	0.923 (0.809 - 1.052)	--	0.945 (0.832 - 1.074)
High School Diploma	0.899** (0.810 - 0.997)	--	0.925 (0.835 - 1.024)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.868** (0.772 - 0.976)	--	0.885** (0.789 - 0.994)
Quintile 4	0.856*** (0.770 - 0.952)	--	0.870*** (0.783 - 0.967)
Quintile 3	0.837*** (0.757 - 0.926)	--	0.838*** (0.759 - 0.924)
Quintile 2	0.936 (0.853 - 1.028)	--	0.948 (0.866 - 1.039)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.002** (1.000 - 1.004)	--	1.003*** (1.001 - 1.005)
Percentage of Low Income	0.996 (0.989 - 1.003)	--	0.997 (0.990 - 1.004)
Percentage of High School Education	1.007*** (1.002 - 1.011)	--	1.004* (0.999 - 1.008)
Percentage of Driving to Work	1.004* (0.999 - 1.009)	--	1.005** (1.000 - 1.010)
Population Density	1 (1.000 - 1.000)	--	1 (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.886*** (0.816 - 0.962)	--	0.915** (0.845 - 0.991)
Occasionally Drinker	1.023 (0.930 - 1.127)	--	0.974 (0.888 - 1.068)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.935 (0.839 - 1.043)	--	1.017 (0.915 - 1.131)
Occasional Smoker	0.821** (0.691 - 0.977)	--	0.851* (0.718 - 1.009)
Former Smoker	0.95 (0.881 - 1.024)	--	0.931* (0.865 - 1.000)
Never Smoker (ref)	--	--	--

Table D.4 Obesity Baron and Kenny Mediation Analysis: Type II Diabetes -- Male

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.044 (0.920 - 1.184)	1.035*** (1.014 - 1.056)	1.045 (0.920 - 1.187)
Intermediate Grocery Stores	1.012 (0.951 - 1.077)	1.008* (0.999 - 1.016)	1.017 (0.954 - 1.084)
Small Grocery and Convenience Stores	1.027 (0.995 - 1.060)	0.994* (0.988 - 1.000)	1.022 (0.990 - 1.054)
Fast-food Restaurants	1.012 (0.990 - 1.033)	1.003 (0.999 - 1.007)	1.013 (0.992 - 1.035)
Full-service Restaurants	1.024 (0.954 - 1.098)	1.002 (0.988 - 1.015)	1.017 (0.949 - 1.089)
Local and Non-chain Restaurants	0.99 (0.979 - 1.002)	0.995*** (0.993 - 0.997)	0.993 (0.981 - 1.004)
Mediator			
Weight Class			
Obese	--	--	3.362*** (2.693 - 4.198)
Overweight	--	--	1.454*** (1.153 - 1.834)
Under and Normal Weight (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.328*** (1.223 - 1.443)	--	1.296*** (1.194 - 1.406)
Age^2	0.998*** (0.997 - 0.999)	--	0.998*** (0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.536** (1.054 - 2.237)	--	1.743*** (1.224 - 2.482)
Length of Residency: +10 years	1.144 (0.951 - 1.376)	--	1.213** (1.013 - 1.452)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.04 (0.829 - 1.305)	--	0.984 (0.790 - 1.225)
Widowed/Separated/ Divorced	0.886 (0.685 - 1.145)	--	0.857 (0.669 - 1.098)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.819** (0.681 - 0.985)	--	0.88 (0.730 - 1.062)
Incomplete Postsecondary Education	1.191 (0.899 - 1.578)	--	1.245 (0.938 - 1.653)
High School Diploma	1.044 (0.821 - 1.327)	--	1.118 (0.884 - 1.415)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.704*** (0.545 - 0.910)	--	0.682*** (0.531 - 0.876)
Quintile 4	0.808* (0.637 - 1.026)	--	0.772** (0.610 - 0.976)
Quintile 3	0.747**	--	0.723***

	(0.593 - 0.940)		(0.578 - 0.905)
Quintile 2	0.904	--	0.884
	(0.721 - 1.134)		(0.713 - 1.094)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.006***	--	1.008***
	(1.002 - 1.010)		(1.004 - 1.012)
Percentage of Low Income	1.004	--	1.003
	(0.988 - 1.021)		(0.988 - 1.019)
Percentage of High School Education	1.009**	--	1.006
	(1.000 - 1.019)		(0.997 - 1.015)
Percentage of Driving to Work	1.002	--	1.003
	(0.992 - 1.013)		(0.992 - 1.013)
Population Density	1	--	1
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.575***	--	0.583***
	(0.478 - 0.691)		(0.488 - 0.697)
Occasionally Drinker	0.965	--	0.923
	(0.787 - 1.184)		(0.759 - 1.122)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.829	--	0.919
	(0.646 - 1.064)		(0.725 - 1.164)
Occasional Smoker	0.709	--	0.748
	(0.426 - 1.180)		(0.444 - 1.258)
Former Smoker	1.014	--	0.968
	(0.836 - 1.230)		(0.802 - 1.168)
Never Smoker (ref)	--	--	--

Table D.5 Obesity Baron and Kenny Mediation Analysis: Cardiovascular Disease -- Male

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.127*	1.035***	1.123
	(0.978 - 1.300)	(1.014 - 1.056)	(0.974 - 1.296)
Intermediate Grocery Stores	0.955	1.008*	0.957
	(0.892 - 1.022)	(0.999 - 1.016)	(0.895 - 1.025)
Small Grocery and Convenience Stores	1.035*	0.994*	1.033*
	(0.996 - 1.075)	(0.988 - 1.000)	(0.995 - 1.073)
Fast-food Restaurants	0.992	1.003	0.992
	(0.966 - 1.019)	(0.999 - 1.007)	(0.966 - 1.018)
Full-service Restaurants	0.96	1.002	0.961
	(0.886 - 1.039)	(0.988 - 1.015)	(0.888 - 1.040)
Local and Non-chain Restaurants	1.001	0.995***	1.002
	(0.989 - 1.012)	(0.993 - 0.997)	(0.990 - 1.013)
Mediator			
Weight Class			
Obese	--	--	1.767***
			(1.415 - 2.207)
Overweight	--	--	1.359***
			(1.076 - 1.716)
Under and Normal Weight (ref)	--	--	--

Individual Level Confounders			
Age			
Age	1.391*** (1.257 - 1.539)	--	1.375*** (1.242 - 1.522)
Age^2	0.998*** (0.997 - 0.999)	--	0.998*** (0.997 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	0.572 (0.289 - 1.133)	--	0.593 (0.299 - 1.176)
Length of Residency: +10 years	0.864 (0.647 - 1.154)	--	0.88 (0.662 - 1.171)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.172 (0.908 - 1.514)	--	1.141 (0.884 - 1.472)
Widowed/Separated/ Divorced	1.064 (0.829 - 1.367)	--	1.047 (0.816 - 1.343)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.82 (0.619 - 1.088)	--	0.848 (0.639 - 1.125)
Incomplete Postsecondary Education	0.951 (0.673 - 1.343)	--	0.965 (0.682 - 1.367)
High School Diploma	0.713** (0.509 - 0.998)	--	0.730* (0.521 - 1.023)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.794 (0.590 - 1.067)	--	0.783* (0.585 - 1.047)
Quintile 4	0.788 (0.593 - 1.048)	--	0.774* (0.585 - 1.025)
Quintile 3	0.953 (0.745 - 1.218)	--	0.939 (0.735 - 1.200)
Quintile 2	0.972 (0.710 - 1.331)	--	0.967 (0.710 - 1.318)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.004 (0.998 - 1.009)	--	1.004 (0.999 - 1.010)
Percentage of Low Income	0.996 (0.977 - 1.016)	--	0.996 (0.977 - 1.016)
Percentage of High School Education	1.006 (0.998 - 1.015)	--	1.005 (0.996 - 1.013)
Percentage of Driving to Work	0.989** (0.979 - 0.999)	--	0.989** (0.979 - 0.999)
Population Density	1.000** (1.000 - 1.000)	--	1.000** (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.832* (0.681 - 1.017)	--	0.835* (0.685 - 1.016)
Occasionally Drinker	1.035 (0.808 - 1.324)	--	1.018 (0.796 - 1.302)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	1.428**	--	1.497**

	(1.013 - 2.011)		(1.064 - 2.106)
Occasional Smoker	1.122	--	1.128
	(0.739 - 1.702)		(0.745 - 1.706)
Former Smoker	1.444***	--	1.408***
	(1.153 - 1.809)		(1.125 - 1.761)
Never Smoker (ref)	--	--	--

Table D.6 Obesity Baron and Kenny Mediation Analysis: Hypertension -- Male

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.037	1.035***	1.038
	(0.960 - 1.120)	(1.014 - 1.056)	(0.960 - 1.123)
Intermediate Grocery Stores	0.978	1.008*	0.982
	(0.948 - 1.008)	(0.999 - 1.016)	(0.953 - 1.012)
Small Grocery and Convenience Stores	1.013	0.994*	1.009
	(0.992 - 1.034)	(0.988 - 1.000)	(0.989 - 1.030)
Fast-food Restaurants	0.992	1.003	0.993
	(0.979 - 1.006)	(0.999 - 1.007)	(0.980 - 1.007)
Full-service Restaurants	1.019	1.002	1.015
	(0.975 - 1.064)	(0.988 - 1.015)	(0.972 - 1.060)
Local and Non-chain Restaurants	1.003	0.995***	1.004
	(0.997 - 1.009)	(0.993 - 0.997)	(0.998 - 1.009)
Mediator			
Weight Class			
Obese	--	--	2.562***
			(2.247 - 2.921)
Overweight	--	--	1.448***
			(1.265 - 1.657)
Under and Normal Weight (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.211***	--	1.191***
	(1.153 - 1.273)		(1.134 - 1.251)
Age^2	0.999***	--	0.999***
	(0.998 - 0.999)		(0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.063	--	1.178
	(0.761 - 1.485)		(0.852 - 1.628)
Length of Residency: +10 years	0.959	--	0.999
	(0.841 - 1.093)		(0.880 - 1.133)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.039	--	0.996
	(0.910 - 1.187)		(0.876 - 1.132)
Widowed/Separated/ Divorced	0.981	--	0.96
	(0.847 - 1.135)		(0.833 - 1.106)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.816***	--	0.860**
	(0.713 - 0.935)		(0.753 - 0.981)
Incomplete Postsecondary Education	0.969	--	0.982

	(0.804 - 1.169)		(0.817 - 1.179)
High School Diploma	0.864*	--	0.897
	(0.735 - 1.014)		(0.768 - 1.049)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.963	--	0.942
	(0.821 - 1.128)		(0.806 - 1.101)
Quintile 4	0.902	--	0.878*
	(0.776 - 1.047)		(0.757 - 1.018)
Quintile 3	0.885	--	0.867*
	(0.756 - 1.037)		(0.743 - 1.011)
Quintile 2	1.039	--	1.034
	(0.896 - 1.205)		(0.893 - 1.198)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.003*	--	1.004**
	(1.000 - 1.006)		(1.001 - 1.007)
Percentage of Low Income	0.996	--	0.996
	(0.986 - 1.006)		(0.986 - 1.006)
Percentage of High School Education	1.008**	--	1.005
	(1.001 - 1.014)		(0.999 - 1.011)
Percentage of Driving to Work	1.005	--	1.005
	(0.998 - 1.012)		(0.998 - 1.012)
Population Density	1	--	1
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.954	--	0.963
	(0.851 - 1.070)		(0.863 - 1.075)
Occasionally Drinker	1.011	--	0.973
	(0.868 - 1.177)		(0.839 - 1.128)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.962	--	1.049
	(0.816 - 1.135)		(0.894 - 1.231)
Occasional Smoker	0.845	--	0.871
	(0.656 - 1.089)		(0.679 - 1.116)
Former Smoker	0.992	--	0.964
	(0.885 - 1.112)		(0.862 - 1.077)
Never Smoker (ref)	--	--	--

Table D.7 Obesity Baron and Kenny Mediation Analysis: Type II Diabetes -- Female

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	0.981	1.029*	0.984
	(0.868 - 1.108)	(0.997 - 1.061)	(0.874 - 1.108)
Intermediate Grocery Stores	1.061*	1.025***	1.060*
	(0.994 - 1.132)	(1.012 - 1.038)	(0.997 - 1.126)
Small Grocery and Convenience Stores	1.03	1.009**	1.024
	(0.990 - 1.071)	(1.001 - 1.018)	(0.987 - 1.063)
Fast-food Restaurants	1.034***	1.010***	1.030***
	(1.014 - 1.055)	(1.004 - 1.016)	(1.010 - 1.051)
Full-service Restaurants	0.982	0.980*	0.991

	(0.916 - 1.052)	(0.960 - 1.001)	(0.926 - 1.061)
Local and Non-chain Restaurants	0.976***	0.992***	0.978***
	(0.964 - 0.988)	(0.989 - 0.995)	(0.968 - 0.989)
Mediator			
Weight Class			
Obese	--	--	4.807***
			(3.603 - 6.413)
Overweight	--	--	1.958***
			(1.428 - 2.686)
Under and Normal Weight (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.331***	--	1.265***
	(1.209 - 1.466)		(1.154 - 1.386)
Age^2	0.998***	--	0.998***
	(0.997 - 0.999)		(0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.191	--	1.426
	(0.625 - 2.270)		(0.754 - 2.700)
Length of Residency: +10 years	1.209*	--	1.325***
	(0.975 - 1.499)		(1.073 - 1.635)
Canadian born (ref)	--	--	--
Marital Status			
Married	0.590***	--	0.626***
	(0.429 - 0.812)		(0.466 - 0.841)
Widowed/Separated/ Divorced	0.652***	--	0.699**
	(0.477 - 0.893)		(0.523 - 0.935)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.753***	--	0.846
	(0.610 - 0.931)		(0.683 - 1.049)
Incomplete Postsecondary Education	0.691**	--	0.760*
	(0.494 - 0.966)		(0.548 - 1.053)
High School Diploma	0.849	--	0.877
	(0.665 - 1.082)		(0.692 - 1.111)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.754	--	0.852
	(0.516 - 1.104)		(0.584 - 1.242)
Quintile 4	0.689***	--	0.758**
	(0.531 - 0.895)		(0.587 - 0.979)
Quintile 3	0.979	--	0.987
	(0.765 - 1.255)		(0.770 - 1.266)
Quintile 2	0.753**	--	0.785**
	(0.605 - 0.937)		(0.634 - 0.971)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.004	--	1.004
	(0.998 - 1.010)		(0.999 - 1.010)
Percentage of Low Income	1.01	--	1.013
	(0.992 - 1.030)		(0.994 - 1.032)
Percentage of High School Education	1.016***	--	1.010*
	(1.005 - 1.027)		(1.000 - 1.021)
Percentage of Driving to Work	1.004	--	1.007
	(0.991 - 1.017)		(0.994 - 1.021)
Population Density	1	--	1

	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.464***	--	0.516***
	(0.376 - 0.572)		(0.418 - 0.637)
Occasionally Drinker	0.972	--	0.891
	(0.777 - 1.215)		(0.716 - 1.109)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	1.007	--	1.116
	(0.787 - 1.289)		(0.876 - 1.421)
Occasional Smoker	0.805	--	0.836
	(0.442 - 1.464)		(0.463 - 1.510)
Former Smoker	1.038	--	0.98
	(0.881 - 1.222)		(0.835 - 1.150)
Never Smoker (ref)	--	--	--

Table D.8 Obesity Baron and Kenny Mediation Analysis: Cardiovascular Disease -- Female

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.008	1.029*	1.01
	(0.877 - 1.159)	(0.997 - 1.061)	(0.880 - 1.159)
Intermediate Grocery Stores	1.022	1.025***	1.024
	(0.967 - 1.081)	(1.012 - 1.038)	(0.969 - 1.081)
Small Grocery and Convenience Stores	0.994	1.009**	0.994
	(0.959 - 1.031)	(1.001 - 1.018)	(0.958 - 1.030)
Fast-food Restaurants	1.011	1.010***	1.01
	(0.987 - 1.036)	(1.004 - 1.016)	(0.986 - 1.034)
Full-service Restaurants	0.994	0.980*	0.998
	(0.914 - 1.081)	(0.960 - 1.001)	(0.918 - 1.085)
Local and Non-chain Restaurants	0.993	0.992***	0.994
	(0.982 - 1.005)	(0.989 - 0.995)	(0.982 - 1.005)
Mediator			
Weight Class			
Obese	--	--	1.642***
			(1.296 - 2.079)
Overweight	--	--	1.288**
			(1.013 - 1.638)
Under and Normal Weight (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.114*	--	1.097
	(0.995 - 1.248)		(0.980 - 1.228)
Age^2	1	--	1
	(0.999 - 1.001)		(0.999 - 1.001)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.145	--	1.229
	(0.476 - 2.758)		(0.512 - 2.950)
Length of Residency: +10 years	0.716**	--	0.735**
	(0.543 - 0.944)		(0.558 - 0.968)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.152	--	1.161

	(0.781 - 1.700)		(0.787 - 1.714)
Widowed/Separated/ Divorced	1.244	--	1.263
	(0.842 - 1.839)		(0.853 - 1.870)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.912	--	0.941
	(0.722 - 1.153)		(0.745 - 1.189)
Incomplete Postsecondary Education	0.727*	--	0.739*
	(0.521 - 1.014)		(0.530 - 1.029)
High School Diploma	1.001	--	1.013
	(0.763 - 1.314)		(0.771 - 1.333)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.489***	--	0.510***
	(0.325 - 0.736)		(0.339 - 0.766)
Quintile 4	0.570***	--	0.589***
	(0.407 - 0.798)		(0.421 - 0.823)
Quintile 3	0.664***	--	0.671***
	(0.504 - 0.875)		(0.510 - 0.883)
Quintile 2	0.826	--	0.839
	(0.656 - 1.040)		(0.667 - 1.054)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	0.996	--	0.996
	(0.989 - 1.003)		(0.989 - 1.003)
Percentage of Low Income	1.008	--	1.008
	(0.989 - 1.028)		(0.990 - 1.028)
Percentage of High School Education	1.001	--	0.999
	(0.988 - 1.013)		(0.987 - 1.012)
Percentage of Driving to Work	1.006	--	1.007
	(0.991 - 1.021)		(0.992 - 1.022)
Population Density	1	--	1
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.645***	--	0.668***
	(0.502 - 0.829)		(0.518 - 0.863)
Occasionally Drinker	1.066	--	1.042
	(0.845 - 1.344)		(0.826 - 1.313)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	1.695***	--	1.774***
	(1.281 - 2.243)		(1.339 - 2.350)
Occasional Smoker	1.547*	--	1.574*
	(0.961 - 2.490)		(0.978 - 2.534)
Former Smoker	1.352***	--	1.328**
	(1.084 - 1.685)		(1.066 - 1.654)
Never Smoker (ref)	--	--	--

Table D.9 Obesity Baron and Kenny Mediation Analysis: Hypertension -- Female

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.009	1.029*	1.016

	(0.950 - 1.072)	(0.997 - 1.061)	(0.958 - 1.078)
Intermediate Grocery Stores	1.022	1.025***	1.022*
	(0.995 - 1.049)	(1.012 - 1.038)	(0.997 - 1.048)
Small Grocery and Convenience Stores	1.012	1.009**	1.01
	(0.994 - 1.031)	(1.001 - 1.018)	(0.993 - 1.028)
Fast-food Restaurants	0.997	1.010***	0.994
	(0.985 - 1.008)	(1.004 - 1.016)	(0.983 - 1.005)
Full-service Restaurants	1.013	0.980*	1.018
	(0.972 - 1.055)	(0.960 - 1.001)	(0.978 - 1.060)
Local and Non-chain Restaurants	0.995*	0.992***	0.996
	(0.989 - 1.000)	(0.989 - 0.995)	(0.991 - 1.001)
Mediator			
Weight Class			
Obese	--	--	2.640***
			(2.340 - 2.979)
Overweight	--	--	1.754***
			(1.546 - 1.990)
Under and Normal Weight (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.218***	--	1.182***
	(1.153 - 1.287)		(1.121 - 1.246)
Age^2	0.999***	--	0.999***
	(0.998 - 0.999)		(0.999 - 1.000)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.163	--	1.302
	(0.817 - 1.655)		(0.936 - 1.813)
Length of Residency: +10 years	1.032	--	1.085
	(0.919 - 1.158)		(0.970 - 1.214)
Canadian born (ref)	--	--	--
Marital Status			
Married	0.873	--	0.893
	(0.742 - 1.028)		(0.765 - 1.042)
Widowed/Separated/ Divorced	0.888	--	0.921
	(0.751 - 1.051)		(0.785 - 1.081)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.841***	--	0.896*
	(0.749 - 0.943)		(0.797 - 1.008)
Incomplete Postsecondary Education	0.892	--	0.914
	(0.745 - 1.067)		(0.770 - 1.086)
High School Diploma	0.943	--	0.961
	(0.829 - 1.073)		(0.844 - 1.094)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.764***	--	0.822**
	(0.629 - 0.926)		(0.681 - 0.991)
Quintile 4	0.830**	--	0.881
	(0.709 - 0.973)		(0.754 - 1.029)
Quintile 3	0.817***	--	0.828***
	(0.722 - 0.926)		(0.732 - 0.935)
Quintile 2	0.869**	--	0.891**
	(0.775 - 0.976)		(0.797 - 0.996)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.002	--	1.002

	(0.999 - 1.005)		(0.999 - 1.005)
Percentage of Low Income	0.997	--	0.998
	(0.988 - 1.006)		(0.989 - 1.007)
Percentage of High School Education	1.006**	--	1.003
	(1.001 - 1.012)		(0.997 - 1.008)
Percentage of Driving to Work	1.003	--	1.004
	(0.997 - 1.009)		(0.998 - 1.010)
Population Density	1	--	1
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.828***	--	0.869**
	(0.738 - 0.929)		(0.778 - 0.972)
Occasionally Drinker	1.028	--	0.971
	(0.909 - 1.161)		(0.863 - 1.094)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.951	--	1.018
	(0.830 - 1.090)		(0.891 - 1.163)
Occasional Smoker	0.824*	--	0.847
	(0.661 - 1.027)		(0.683 - 1.051)
Former Smoker	0.953	--	0.93
	(0.860 - 1.056)		(0.844 - 1.025)
Never Smoker (ref)	--	--	--

Appendix E: Baron and Kenny Regression Tables: Fruits & Vegetables Consumption

Table E.1 Fruits & vegetables Consumption Baron and Kenny Mediation Analysis: Type II Diabetes -- Overall

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.018 (0.931 - 1.114)	0.999 (0.968 - 1.030)	1.021 (0.934 - 1.117)
Intermediate Grocery Stores	1.032 (0.986 - 1.080)	1 (0.985 - 1.011)	1.032 (0.986 - 1.080)
Small Grocery and Convenience Stores	1.029** (1.003 - 1.056)	0.999 (0.991 - 1.007)	1.029** (1.003 - 1.056)
Fast-food Restaurants	1.020** (1.005 - 1.035)	0.987*** (0.982 - 0.993)	1.019** (1.004 - 1.035)
Full-service Restaurants	1.011 (0.960 - 1.064)	1.029*** (1.009 - 1.049)	1.013 (0.963 - 1.066)
Local and Non-chain Restaurants	0.984*** (0.975 - 0.994)	1.001 (0.998 - 1.003)	0.984*** (0.975 - 0.993)
Mediator			
Fruits & vegetables Consumption			
5 or More Daily Servings	--	--	0.840*** (0.746 - 0.945)
Less than 5 Daily Servings (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.330*** (1.249 - 1.417)	--	1.328*** (1.247 - 1.415)
Age^2	0.998*** (0.997 - 0.999)	--	0.998*** (0.998 - 0.999)
Gender			
Female	0.572*** (0.510 - 0.643)	--	0.587*** (0.522 - 0.660)
Male (ref)	--	--	--
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.422** (1.026 - 1.969)	--	1.413** (1.020 - 1.958)
Length of Residency: +10 years	1.172** (1.015 - 1.353)	--	1.180** (1.022 - 1.362)
Canadian born (ref)	--	--	--
Marital Status			
Married	0.813* (0.659 - 1.003)	--	0.821* (0.667 - 1.010)
Widowed/Separated/ Divorced	0.781** (0.627 - 0.974)	--	0.781** (0.628 - 0.972)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.791*** (0.689 - 0.908)	--	0.804*** (0.699 - 0.924)
Incomplete Postsecondary Education	0.962 (0.775 - 1.194)	--	0.975 (0.785 - 1.211)
High School Diploma	0.955 (0.802 - 1.139)	--	0.962 (0.807 - 1.146)

Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.722*** (0.586 - 0.891)	--	0.726*** (0.589 - 0.894)
Quintile 4	0.767*** (0.643 - 0.916)	--	0.766*** (0.642 - 0.915)
Quintile 3	0.824** (0.695 - 0.978)	--	0.824** (0.695 - 0.978)
Quintile 2	0.833** (0.709 - 0.979)	--	0.832** (0.708 - 0.976)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.005*** (1.002 - 1.009)	--	1.005*** (1.002 - 1.009)
Percentage of Low Income	1.007 (0.994 - 1.019)	--	1.006 (0.994 - 1.019)
Percentage of High School Education	1.012*** (1.005 - 1.019)	--	1.012*** (1.005 - 1.019)
Percentage of Driving to Work	1.003 (0.995 - 1.012)	--	1.003 (0.994 - 1.011)
Population Density	1 (1.000 - 1.000)	--	1 (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.532*** (0.463 - 0.611)	--	0.534*** (0.465 - 0.613)
Occasionally Drinker	0.982 (0.841 - 1.147)	--	0.984 (0.843 - 1.148)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.886 (0.740 - 1.062)	--	0.861 (0.717 - 1.035)
Occasional Smoker	0.746 (0.502 - 1.109)	--	0.743 (0.499 - 1.106)
Former Smoker	1.029 (0.900 - 1.176)	--	1.025 (0.897 - 1.172)
Never Smoker (ref)	--	--	--

Table E.2 Fruits & vegetables Consumption Baron and Kenny Mediation Analysis: Cardiovascular Disease -- Overall

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.081 (0.974 - 1.199)	0.999 (0.968 - 1.030)	1.082 (0.975 - 1.200)
Intermediate Grocery Stores	0.981 (0.936 - 1.029)	1 (0.985 - 1.011)	0.981 (0.936 - 1.029)
Small Grocery and Convenience Stores	1.017 (0.989 - 1.046)	0.999 (0.991 - 1.007)	1.018 (0.990 - 1.046)
Fast-food Restaurants	0.999 (0.980 - 1.019)	0.987*** (0.982 - 0.993)	0.999 (0.980 - 1.018)
Full-service Restaurants	0.976 (0.920 - 1.034)	1.029*** (1.009 - 1.049)	0.976 (0.921 - 1.035)
Local and Non-chain Restaurants	0.998	1.001	0.998

	(0.989 - 1.006)	(0.998 - 1.003)	(0.989 - 1.006)
Mediator			
Fruits & vegetables Consumption			
5 or More Daily Servings	--	--	0.954
			(0.845 - 1.077)
Less than 5 Daily Servings (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.265***		1.264***
	(1.170 - 1.368)		(1.169 - 1.367)
Age^2	0.999***		0.999***
	(0.998 - 0.999)		(0.998 - 0.999)
Gender			
Female	0.542***	--	0.546***
	(0.481 - 0.611)		(0.484 - 0.616)
Male (ref)	--	--	--
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	0.732	--	0.729
	(0.428 - 1.252)		(0.427 - 1.246)
Length of Residency: +10 years	0.823*	--	0.824*
	(0.657 - 1.030)		(0.658 - 1.033)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.186	--	1.189
	(0.954 - 1.474)		(0.956 - 1.479)
Widowed/Separated/ Divorced	1.195	--	1.196
	(0.961 - 1.486)		(0.961 - 1.487)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.85	--	0.853
	(0.692 - 1.044)		(0.696 - 1.046)
Incomplete Postsecondary Education	0.855	--	0.857
	(0.659 - 1.108)		(0.662 - 1.110)
High School Diploma	0.812*	--	0.812*
	(0.641 - 1.029)		(0.641 - 1.029)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.687***	--	0.688***
	(0.547 - 0.864)		(0.547 - 0.865)
Quintile 4	0.693***	--	0.693***
	(0.560 - 0.858)		(0.560 - 0.857)
Quintile 3	0.820**	--	0.819**
	(0.683 - 0.984)		(0.682 - 0.984)
Quintile 2	0.895	--	0.895
	(0.727 - 1.103)		(0.726 - 1.102)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.001		1.001
	(0.997 - 1.006)		(0.997 - 1.006)
Percentage of Low Income	1.001		1.001
	(0.987 - 1.015)		(0.987 - 1.015)
Percentage of High School Education	1.004		1.004
	(0.997 - 1.012)		(0.997 - 1.012)
Percentage of Driving to Work	0.995		0.995
	(0.987 - 1.003)		(0.987 - 1.003)
Population Density	1.000*		1.000*

	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.755***	--	0.756***
	(0.643 - 0.885)		(0.644 - 0.887)
Occasionally Drinker	1.062	--	1.063
	(0.897 - 1.257)		(0.898 - 1.259)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	1.522***	--	1.510***
	(1.203 - 1.927)		(1.197 - 1.905)
Occasional Smoker	1.273	--	1.27
	(0.930 - 1.741)		(0.928 - 1.738)
Former Smoker	1.431***	--	1.430***
	(1.222 - 1.676)		(1.221 - 1.674)
Never Smoker (ref)	--	--	--

Table E.3 Fruits & vegetables Consumption Baron and Kenny Mediation Analysis: Hypertension -- Overall

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.024	0.999	1.027
	(0.975 - 1.076)	(0.968 - 1.030)	(0.977 - 1.079)
Intermediate Grocery Stores	0.998	1	0.999
	(0.978 - 1.019)	(0.985 - 1.011)	(0.978 - 1.020)
Small Grocery and Convenience Stores	1.013*	0.999	1.013*
	(0.998 - 1.027)	(0.991 - 1.007)	(0.998 - 1.027)
Fast-food Restaurants	0.994	0.987***	0.994
	(0.985 - 1.003)	(0.982 - 0.993)	(0.985 - 1.003)
Full-service Restaurants	1.016	1.029***	1.018
	(0.986 - 1.048)	(1.009 - 1.049)	(0.988 - 1.049)
Local and Non-chain Restaurants	0.999	1.001	0.999
	(0.995 - 1.003)	(0.998 - 1.003)	(0.995 - 1.003)
Mediator			
Fruits & vegetables Consumption			
5 or More Daily Servings	--	--	0.884***
			(0.827 - 0.944)
Less than 5 Daily Servings (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.207***	--	1.206***
	(1.164 - 1.252)		(1.163 - 1.250)
Age^2	0.999***	--	0.999***
	(0.999 - 0.999)		(0.999 - 0.999)
Gender			
Female	0.876***	--	0.893***
	(0.823 - 0.932)		(0.839 - 0.951)
Male (ref)	--	--	--
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.087	--	1.082
	(0.850 - 1.390)		(0.845 - 1.384)
Length of Residency: +10 years	0.987	--	0.99
	(0.901 - 1.080)		(0.905 - 1.084)

Canadian born (ref)	--	--	--
Marital Status			
Married	0.948 (0.851 - 1.056)	--	0.954 (0.856 - 1.062)
Widowed/Separated/ Divorced	0.956 (0.851 - 1.073)	--	0.956 (0.852 - 1.072)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.817*** (0.747 - 0.894)	--	0.826*** (0.754 - 0.905)
Incomplete Postsecondary Education	0.923 (0.809 - 1.052)	--	0.93 (0.816 - 1.061)
High School Diploma	0.899** (0.810 - 0.997)	--	0.901** (0.812 - 1.000)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.868** (0.772 - 0.976)	--	0.872** (0.775 - 0.981)
Quintile 4	0.856*** (0.770 - 0.952)	--	0.856*** (0.770 - 0.953)
Quintile 3	0.837*** (0.757 - 0.926)	--	0.838*** (0.758 - 0.927)
Quintile 2	0.936 (0.853 - 1.028)	--	0.936 (0.852 - 1.027)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.002** (1.000 - 1.004)	--	1.002** (1.000 - 1.004)
Percentage of Low Income	0.996 (0.989 - 1.003)	--	0.996 (0.989 - 1.003)
Percentage of High School Education	1.007*** (1.002 - 1.011)	--	1.007*** (1.002 - 1.011)
Percentage of Driving to Work	1.004* (0.999 - 1.009)	--	1.004* (0.999 - 1.009)
Population Density	1 (1.000 - 1.000)	--	1 (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.886*** (0.816 - 0.962)	--	0.890*** (0.820 - 0.966)
Occasionally Drinker	1.023 (0.930 - 1.127)	--	1.024 (0.931 - 1.127)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.935 (0.839 - 1.043)	--	0.916 (0.820 - 1.023)
Occasional Smoker	0.821** (0.691 - 0.977)	--	0.817** (0.688 - 0.971)
Former Smoker	0.95 (0.881 - 1.024)	--	0.947 (0.879 - 1.021)
Never Smoker (ref)	--	--	--

Table E.4 Fruits & vegetables Consumption Baron and Kenny Mediation Analysis: Type II Diabetes -- Males

Variables	Step 1	Step 2	Step 3

	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.044 (0.920 - 1.184)	0.974 (0.922 - 1.028)	1.045 (0.921 - 1.185)
Intermediate Grocery Stores	1.012 (0.951 - 1.077)	0.988 (0.966 - 1.010)	1.011 (0.951 - 1.076)
Small Grocery and Convenience Stores	1.027 (0.995 - 1.060)	1.011* (0.998 - 1.024)	1.027* (0.995 - 1.060)
Fast-food Restaurants	1.012 (0.990 - 1.033)	0.989** (0.979 - 0.998)	1.011 (0.990 - 1.033)
Full-service Restaurants	1.024 (0.954 - 1.098)	1.041** (1.008 - 1.076)	1.025 (0.956 - 1.100)
Local and Non-chain Restaurants	0.99 (0.979 - 1.002)	1 (0.997 - 1.004)	0.99 (0.979 - 1.002)
Mediator			
Fruits & vegetables Consumption			
5 or More Daily Servings	--	--	0.899 (0.771 - 1.048)
Less than 5 Daily Servings (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.328*** (1.223 - 1.443)	--	1.326*** (1.221 - 1.441)
Age^2	0.998*** (0.997 - 0.999)	--	0.998*** (0.997 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.536** (1.054 - 2.237)	--	1.530** (1.049 - 2.231)
Length of Residency: +10 years	1.144 (0.951 - 1.376)	--	1.152 (0.958 - 1.385)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.04 (0.829 - 1.305)	--	1.045 (0.832 - 1.312)
Widowed/Separated/ Divorced	0.886 (0.685 - 1.145)	--	0.884 (0.684 - 1.144)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.819** (0.681 - 0.985)	--	0.824** (0.684 - 0.993)
Incomplete Postsecondary Education	1.191 (0.899 - 1.578)	--	1.197 (0.903 - 1.587)
High School Diploma	1.044 (0.821 - 1.327)	--	1.047 (0.823 - 1.331)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.704*** (0.545 - 0.910)	--	0.705*** (0.546 - 0.911)
Quintile 4	0.808* (0.637 - 1.026)	--	0.805* (0.634 - 1.023)
Quintile 3	0.747** (0.593 - 0.940)	--	0.746** (0.592 - 0.939)
Quintile 2	0.904 (0.721 - 1.134)	--	0.903 (0.720 - 1.132)
Quintile 1 (ref)	--	--	--

Neighbourhood Level Covariates			
Percentage of Visual Minority	1.006*** (1.002 - 1.010)	--	1.006*** (1.002 - 1.010)
Percentage of Low Income	1.004 (0.988 - 1.021)	--	1.004 (0.988 - 1.021)
Percentage of High School Education	1.009** (1.000 - 1.019)	--	1.009** (1.000 - 1.019)
Percentage of Driving to Work	1.002 (0.992 - 1.013)	--	1.002 (0.991 - 1.013)
Population Density	1 (1.000 - 1.000)	--	1 (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.575*** (0.478 - 0.691)	--	0.576*** (0.479 - 0.692)
Occasionally Drinker	0.965 (0.787 - 1.184)	--	0.967 (0.789 - 1.186)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.829 (0.646 - 1.064)	--	0.816 (0.633 - 1.051)
Occasional Smoker	0.709 (0.426 - 1.180)	--	0.709 (0.425 - 1.182)
Former Smoker	1.014 (0.836 - 1.230)	--	1.012 (0.835 - 1.228)
Never Smoker (ref)	--	--	--

Table E.5 Fruits & vegetables Consumption Baron and Kenny Mediation Analysis: Cardiovascular Disease -- Males

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.127* (0.978 - 1.300)	0.974 (0.922 - 1.028)	1.128* (0.978 - 1.300)
Intermediate Grocery Stores	0.955 (0.892 - 1.022)	0.988 (0.966 - 1.010)	0.954 (0.892 - 1.021)
Small Grocery and Convenience Stores	1.035* (0.996 - 1.075)	1.011* (0.998 - 1.024)	1.035* (0.996 - 1.075)
Fast-food Restaurants	0.992 (0.966 - 1.019)	0.989** (0.979 - 0.998)	0.992 (0.966 - 1.018)
Full-service Restaurants	0.96 (0.886 - 1.039)	1.041** (1.008 - 1.076)	0.96 (0.887 - 1.040)
Local and Non-chain Restaurants	1.001 (0.989 - 1.012)	1 (0.997 - 1.004)	1.001 (0.990 - 1.012)
Mediator			
Fruits & vegetables Consumption			
5 or More Daily Servings	--	--	0.952 (0.809 - 1.121)
Less than 5 Daily Servings (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.391*** (1.257 - 1.539)	--	1.390*** (1.256 - 1.537)
Age^2	0.998***	--	0.998***

	(0.997 - 0.999)		(0.997 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	0.572	--	0.57
	(0.289 - 1.133)		(0.289 - 1.125)
Length of Residency: +10 years	0.864	--	0.866
	(0.647 - 1.154)		(0.647 - 1.158)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.172	--	1.176
	(0.908 - 1.514)		(0.909 - 1.521)
Widowed/Separated/ Divorced	1.064	--	1.064
	(0.829 - 1.367)		(0.828 - 1.367)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.82	--	0.823
	(0.619 - 1.088)		(0.622 - 1.088)
Incomplete Postsecondary Education	0.951	--	0.952
	(0.673 - 1.343)		(0.674 - 1.344)
High School Diploma	0.713**	--	0.713**
	(0.509 - 0.998)		(0.509 - 0.997)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.794	--	0.793
	(0.590 - 1.067)		(0.590 - 1.067)
Quintile 4	0.788	--	0.786*
	(0.593 - 1.048)		(0.592 - 1.045)
Quintile 3	0.953	--	0.951
	(0.745 - 1.218)		(0.744 - 1.215)
Quintile 2	0.972	--	0.971
	(0.710 - 1.331)		(0.710 - 1.327)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.004	--	1.004
	(0.998 - 1.009)		(0.998 - 1.009)
Percentage of Low Income	0.996	--	0.996
	(0.977 - 1.016)		(0.977 - 1.016)
Percentage of High School Education	1.006	--	1.006
	(0.998 - 1.015)		(0.998 - 1.015)
Percentage of Driving to Work	0.989**	--	0.989**
	(0.979 - 0.999)		(0.979 - 0.999)
Population Density	1.000**	--	1.000**
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.832*	--	0.833*
	(0.681 - 1.017)		(0.681 - 1.019)
Occasionally Drinker	1.035	--	1.036
	(0.808 - 1.324)		(0.809 - 1.326)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	1.428**	--	1.417**
	(1.013 - 2.011)		(1.011 - 1.985)
Occasional Smoker	1.122	--	1.121
	(0.739 - 1.702)		(0.738 - 1.702)
Former Smoker	1.444***	--	1.443***
	(1.153 - 1.809)		(1.152 - 1.807)

Never Smoker (ref)	--	--	--

Table E.6 Fruits & vegetables Consumption Baron and Kenny Mediation Analysis: Hypertension -- Males

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.037 (0.960 - 1.120)	0.974 (0.922 - 1.028)	1.038 (0.961 - 1.121)
Intermediate Grocery Stores	0.978 (0.948 - 1.008)	0.988 (0.966 - 1.010)	0.977 (0.948 - 1.008)
Small Grocery and Convenience Stores	1.013 (0.992 - 1.034)	1.011* (0.998 - 1.024)	1.013 (0.992 - 1.034)
Fast-food Restaurants	0.992 (0.979 - 1.006)	0.989** (0.979 - 0.998)	0.992 (0.979 - 1.006)
Full-service Restaurants	1.019 (0.975 - 1.064)	1.041** (1.008 - 1.076)	1.02 (0.976 - 1.065)
Local and Non-chain Restaurants	1.003 (0.997 - 1.009)	1 (0.997 - 1.004)	1.003 (0.997 - 1.009)
Mediator			
Fruits & vegetables Consumption			
5 or More Daily Servings	--	--	0.903** (0.819 - 0.996)
Less than 5 Daily Servings (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.211*** (1.153 - 1.273)	--	1.210*** (1.152 - 1.271)
Age^2	0.999*** (0.998 - 0.999)	--	0.999*** (0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.063 (0.761 - 1.485)	--	1.059 (0.757 - 1.482)
Length of Residency: +10 years	0.959 (0.841 - 1.093)	--	0.964 (0.846 - 1.098)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.039 (0.910 - 1.187)	--	1.044 (0.914 - 1.192)
Widowed/Separated/ Divorced	0.981 (0.847 - 1.135)	--	0.979 (0.846 - 1.133)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.816*** (0.713 - 0.935)	--	0.821*** (0.716 - 0.941)
Incomplete Postsecondary Education	0.969 (0.804 - 1.169)	--	0.972 (0.806 - 1.173)
High School Diploma	0.864* (0.735 - 1.014)	--	0.863* (0.735 - 1.013)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.963 (0.821 - 1.128)	--	0.964 (0.823 - 1.130)
Quintile 4	0.902	--	0.899

	(0.776 - 1.047)		(0.774 - 1.045)
Quintile 3	0.885	--	0.884
	(0.756 - 1.037)		(0.754 - 1.035)
Quintile 2	1.039	--	1.037
	(0.896 - 1.205)		(0.894 - 1.203)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.003*	--	1.003*
	(1.000 - 1.006)		(1.000 - 1.006)
Percentage of Low Income	0.996	--	0.996
	(0.986 - 1.006)		(0.986 - 1.006)
Percentage of High School Education	1.008**	--	1.008**
	(1.001 - 1.014)		(1.001 - 1.014)
Percentage of Driving to Work	1.005	--	1.005
	(0.998 - 1.012)		(0.998 - 1.012)
Population Density	1	--	1
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.954	--	0.956
	(0.851 - 1.070)		(0.852 - 1.072)
Occasionally Drinker	1.011	--	1.012
	(0.868 - 1.177)		(0.869 - 1.178)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.962	--	0.947
	(0.816 - 1.135)		(0.801 - 1.120)
Occasional Smoker	0.845	--	0.844
	(0.656 - 1.089)		(0.656 - 1.087)
Former Smoker	0.992	--	0.989
	(0.885 - 1.112)		(0.883 - 1.108)
Never Smoker (ref)	--	--	--

Table E.7 Fruits & vegetables Consumption Baron and Kenny Mediation Analysis: Type II Diabetes -- Females

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	0.981	1.016	0.988
	(0.868 - 1.108)	(0.979 - 1.054)	(0.874 - 1.116)
Intermediate Grocery Stores	1.061*	1.001	1.063*
	(0.994 - 1.132)	(0.985 - 1.016)	(0.996 - 1.134)
Small Grocery and Convenience Stores	1.03	0.990*	1.029
	(0.990 - 1.071)	(0.980 - 1.001)	(0.990 - 1.069)
Fast-food Restaurants	1.034***	0.985***	1.033***
	(1.014 - 1.055)	(0.978 - 0.992)	(1.013 - 1.053)
Full-service Restaurants	0.982	1.017	0.985
	(0.916 - 1.052)	(0.994 - 1.041)	(0.918 - 1.056)
Local and Non-chain Restaurants	0.976***	1.002	0.976***
	(0.964 - 0.988)	(0.999 - 1.005)	(0.964 - 0.988)
Mediator			
Fruits & vegetables Consumption			
5 or More Daily Servings	--	--	0.775***
			(0.652 - 0.922)

Less than 5 Daily Servings (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.331*** (1.209 - 1.466)	--	1.330*** (1.208 - 1.463)
Age^2	0.998*** (0.997 - 0.999)	--	0.998*** (0.997 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.191 (0.625 - 2.270)	--	1.184 (0.621 - 2.259)
Length of Residency: +10 years	1.209* (0.975 - 1.499)	--	1.207* (0.974 - 1.495)
Canadian born (ref)	--	--	--
Marital Status			
Married	0.590*** (0.429 - 0.812)	--	0.602*** (0.441 - 0.822)
Widowed/Separated/ Divorced	0.652*** (0.477 - 0.893)	--	0.658*** (0.484 - 0.895)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.753*** (0.610 - 0.931)	--	0.777** (0.627 - 0.964)
Incomplete Postsecondary Education	0.691** (0.494 - 0.966)	--	0.711** (0.509 - 0.993)
High School Diploma	0.849 (0.665 - 1.082)	--	0.861 (0.677 - 1.094)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.754 (0.516 - 1.104)	--	0.766 (0.524 - 1.120)
Quintile 4	0.689*** (0.531 - 0.895)	--	0.694*** (0.535 - 0.900)
Quintile 3	0.979 (0.765 - 1.255)	--	0.986 (0.771 - 1.261)
Quintile 2	0.753** (0.605 - 0.937)	--	0.751*** (0.604 - 0.932)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.004 (0.998 - 1.010)	--	1.004 (0.998 - 1.010)
Percentage of Low Income	1.01 (0.992 - 1.030)	--	1.01 (0.992 - 1.029)
Percentage of High School Education	1.016*** (1.005 - 1.027)	--	1.016*** (1.006 - 1.027)
Percentage of Driving to Work	1.004 (0.991 - 1.017)	--	1.003 (0.991 - 1.016)
Population Density	1 (1.000 - 1.000)	--	1 (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.464*** (0.376 - 0.572)	--	0.468*** (0.380 - 0.576)
Occasionally Drinker	0.972 (0.777 - 1.215)	--	0.97 (0.779 - 1.209)
Non Drinker (ref)	--	--	--
Smoking Status			

Daily Smoker	1.007 (0.787 - 1.289)	--	0.96 (0.747 - 1.233)
Occasional Smoker	0.805 (0.442 - 1.464)	--	0.786 (0.432 - 1.428)
Former Smoker	1.038 (0.881 - 1.222)	--	1.029 (0.874 - 1.212)
Never Smoker (ref)	--	--	--

Table E.8 Fruits & vegetables Consumption Baron and Kenny Mediation Analysis: Cardiovascular Disease -- Females

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.008 (0.877 - 1.159)	1.016 (0.979 - 1.054)	1.009 (0.878 - 1.159)
Intermediate Grocery Stores	1.022 (0.967 - 1.081)	1.001 (0.985 - 1.016)	1.023 (0.967 - 1.081)
Small Grocery and Convenience Stores	0.994 (0.959 - 1.031)	0.990* (0.980 - 1.001)	0.994 (0.959 - 1.030)
Fast-food Restaurants	1.011 (0.987 - 1.036)	0.985*** (0.978 - 0.992)	1.011 (0.987 - 1.036)
Full-service Restaurants	0.994 (0.914 - 1.081)	1.017 (0.994 - 1.041)	0.995 (0.915 - 1.082)
Local and Non-chain Restaurants	0.993 (0.982 - 1.005)	1.002 (0.999 - 1.005)	0.993 (0.982 - 1.005)
Mediator			
Fruits & vegetables Consumption			
5 or More Daily Servings	--	--	0.974 (0.819 - 1.159)
Less than 5 Daily Servings (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.114* (0.995 - 1.248)	--	1.114* (0.995 - 1.248)
Age^2	1 (0.999 - 1.001)	--	1 (0.999 - 1.001)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.145 (0.476 - 2.758)	--	1.144 (0.475 - 2.752)
Length of Residency: +10 years	0.716** (0.543 - 0.944)	--	0.716** (0.543 - 0.944)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.152 (0.781 - 1.700)	--	1.154 (0.781 - 1.707)
Widowed/Separated/ Divorced	1.244 (0.842 - 1.839)	--	1.245 (0.842 - 1.843)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.912 (0.722 - 1.153)	--	0.915 (0.725 - 1.155)
Incomplete Postsecondary Education	0.727* (0.521 - 1.014)	--	0.729* (0.523 - 1.015)
High School Diploma	1.001	--	1.002

	(0.763 - 1.314)		(0.764 - 1.315)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.489***	--	0.490***
	(0.325 - 0.736)		(0.326 - 0.735)
Quintile 4	0.570***	--	0.570***
	(0.407 - 0.798)		(0.408 - 0.798)
Quintile 3	0.664***	--	0.665***
	(0.504 - 0.875)		(0.505 - 0.875)
Quintile 2	0.826	--	0.826
	(0.656 - 1.040)		(0.656 - 1.039)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	0.996	--	0.996
	(0.989 - 1.003)		(0.989 - 1.003)
Percentage of Low Income	1.008	--	1.008
	(0.989 - 1.028)		(0.989 - 1.028)
Percentage of High School Education	1.001	--	1.001
	(0.988 - 1.013)		(0.988 - 1.013)
Percentage of Driving to Work	1.006	--	1.006
	(0.991 - 1.021)		(0.991 - 1.021)
Population Density	1	--	1
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.645***	--	0.646***
	(0.502 - 0.829)		(0.502 - 0.831)
Occasionally Drinker	1.066	--	1.066
	(0.845 - 1.344)		(0.845 - 1.346)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	1.695***	--	1.686***
	(1.281 - 2.243)		(1.275 - 2.229)
Occasional Smoker	1.547*	--	1.543*
	(0.961 - 2.490)		(0.958 - 2.484)
Former Smoker	1.352***	--	1.350***
	(1.084 - 1.685)		(1.083 - 1.684)
Never Smoker (ref)	--	--	--

Table E.9 Fruits & vegetables Consumption Baron and Kenny Mediation Analysis: Hypertension -- Females

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.009	1.016	1.013
	(0.950 - 1.072)	(0.979 - 1.054)	(0.954 - 1.076)
Intermediate Grocery Stores	1.022	1.001	1.023*
	(0.995 - 1.049)	(0.985 - 1.016)	(0.996 - 1.051)
Small Grocery and Convenience Stores	1.012	0.990*	1.012
	(0.994 - 1.031)	(0.980 - 1.001)	(0.994 - 1.030)
Fast-food Restaurants	0.997	0.985***	0.996
	(0.985 - 1.008)	(0.978 - 0.992)	(0.985 - 1.007)
Full-service Restaurants	1.013	1.017	1.014
	(0.972 - 1.055)	(0.994 - 1.041)	(0.973 - 1.057)

Local and Non-chain Restaurants	0.995* (0.989 - 1.000)	1.002 (0.999 - 1.005)	0.995* (0.989 - 1.000)
Mediator			
Fruits & vegetables Consumption			
5 or More Daily Servings	--	--	0.868*** (0.796 - 0.946)
Less than 5 Daily Servings (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.218*** (1.153 - 1.287)	--	1.218*** (1.152 - 1.286)
Age^2	0.999*** (0.998 - 0.999)	--	0.999*** (0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.163 (0.817 - 1.655)	--	1.157 (0.813 - 1.646)
Length of Residency: +10 years	1.032 (0.919 - 1.158)	--	1.031 (0.918 - 1.158)
Canadian born (ref)	--	--	--
Marital Status			
Married	0.873 (0.742 - 1.028)	--	0.882 (0.750 - 1.036)
Widowed/Separated/ Divorced	0.888 (0.751 - 1.051)	--	0.892 (0.754 - 1.054)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.841*** (0.749 - 0.943)	--	0.855*** (0.762 - 0.959)
Incomplete Postsecondary Education	0.892 (0.745 - 1.067)	--	0.905 (0.757 - 1.081)
High School Diploma	0.943 (0.829 - 1.073)	--	0.949 (0.835 - 1.079)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.764*** (0.629 - 0.926)	--	0.770*** (0.635 - 0.935)
Quintile 4	0.830** (0.709 - 0.973)	--	0.834** (0.712 - 0.977)
Quintile 3	0.817*** (0.722 - 0.926)	--	0.821*** (0.725 - 0.929)
Quintile 2	0.869** (0.775 - 0.976)	--	0.869** (0.775 - 0.976)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.002 (0.999 - 1.005)	--	1.002 (0.999 - 1.004)
Percentage of Low Income	0.997 (0.988 - 1.006)	--	0.997 (0.988 - 1.006)
Percentage of High School Education	1.006** (1.001 - 1.012)	--	1.006** (1.000 - 1.012)
Percentage of Driving to Work	1.003 (0.997 - 1.009)	--	1.003 (0.997 - 1.009)
Population Density	1 (1.000 - 1.000)	--	1 (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			

Regular Drinker	0.828***	--	0.833***
	(0.738 - 0.929)		(0.743 - 0.934)
Occasionally Drinker	1.028	--	1.028
	(0.909 - 1.161)		(0.910 - 1.161)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.951	--	0.924
	(0.830 - 1.090)		(0.807 - 1.059)
Occasional Smoker	0.824*	--	0.813*
	(0.661 - 1.027)		(0.653 - 1.011)
Former Smoker	0.953	--	0.949
	(0.860 - 1.056)		(0.857 - 1.051)
Never Smoker (ref)	--	--	--

Appendix F: Baron and Kenny Regression Tables: Physical Activity Levels

Table F.1 Physical Activity Level Baron and Kenny Mediation Analysis: Type II Diabetes -- Overall

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.018 (0.931 - 1.114)	1 (0.993 - 1.024)	1.017 (0.930 - 1.113)
Intermediate Grocery Stores	1.032 (0.986 - 1.080)	1.011*** (1.004 - 1.018)	1.032 (0.985 - 1.080)
Small Grocery and Convenience Stores	1.029** (1.003 - 1.056)	1.013*** (1.009 - 1.017)	1.026* (0.999 - 1.053)
Fast-food Restaurants	1.020** (1.005 - 1.035)	0.997** (0.994 - 1.000)	1.020** (1.004 - 1.035)
Full-service Restaurants	1.011 (0.960 - 1.064)	1.017*** (1.006 - 1.027)	1.008 (0.957 - 1.061)
Local and Non-chain Restaurants	0.984*** (0.975 - 0.994)	0.995*** (0.994 - 0.996)	0.985*** (0.976 - 0.994)
Mediator			
Physical Activity Level			
Physically Active	--	--	0.594*** (0.509 - 0.694)
Moderately Active	--	--	0.792*** (0.694 - 0.904)
Inactive (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.330*** (1.249 - 1.417)	--	1.328*** (1.247 - 1.415)
Age^2	0.998*** (0.997 - 0.999)	--	0.998*** (0.998 - 0.999)
Gender			
Female	0.572*** (0.510 - 0.643)	--	0.562*** (0.501 - 0.631)
Male (ref)	--	--	--
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.422** (1.026 - 1.969)	--	1.381* (0.999 - 1.909)
Length of Residency: +10 years	1.172** (1.015 - 1.353)	--	1.160** (1.005 - 1.337)
Canadian born (ref)	--	--	--
Marital Status			
Married	0.813* (0.659 - 1.003)	--	0.811** (0.658 - 0.999)
Widowed/Separated/ Divorced	0.781** (0.627 - 0.974)	--	0.784** (0.630 - 0.975)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.791*** (0.689 - 0.908)	--	0.828*** (0.721 - 0.951)
Incomplete Postsecondary Education	0.962 (0.775 - 1.194)	--	0.982 (0.792 - 1.218)

High School Diploma	0.955	--	0.972
	(0.802 - 1.139)		(0.816 - 1.158)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.722***	--	0.750***
	(0.586 - 0.891)		(0.609 - 0.924)
Quintile 4	0.767***	--	0.785***
	(0.643 - 0.916)		(0.659 - 0.937)
Quintile 3	0.824**	--	0.835**
	(0.695 - 0.978)		(0.704 - 0.991)
Quintile 2	0.833**	--	0.844**
	(0.709 - 0.979)		(0.719 - 0.990)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.005***	--	1.005**
	(1.002 - 1.009)		(1.001 - 1.008)
Percentage of Low Income	1.007	--	1.007
	(0.994 - 1.019)		(0.995 - 1.020)
Percentage of High School Education	1.012***	--	1.011***
	(1.005 - 1.019)		(1.004 - 1.018)
Percentage of Driving to Work	1.003	--	1.003
	(0.995 - 1.012)		(0.994 - 1.011)
Population Density	1	--	1
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.532***	--	0.551***
	(0.463 - 0.611)		(0.480 - 0.633)
Occasionally Drinker	0.982	--	0.978
	(0.841 - 1.147)		(0.838 - 1.141)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.886	--	0.844*
	(0.740 - 1.062)		(0.705 - 1.012)
Occasional Smoker	0.746	--	0.743
	(0.502 - 1.109)		(0.503 - 1.097)
Former Smoker	1.029	--	1.033
	(0.900 - 1.176)		(0.904 - 1.181)
Never Smoker (ref)	--	--	--

Table F.2 Physical Activity Level Baron and Kenny Mediation Analysis: Cardiovascular Disease -- Overall

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.081	1	1.08
	(0.974 - 1.199)	(0.993 - 1.024)	(0.973 - 1.198)
Intermediate Grocery Stores	0.981	1.011***	0.981
	(0.936 - 1.029)	(1.004 - 1.018)	(0.936 - 1.028)
Small Grocery and Convenience Stores	1.017	1.013***	1.015
	(0.989 - 1.046)	(1.009 - 1.017)	(0.987 - 1.044)
Fast-food Restaurants	0.999	0.997**	1
	(0.980 - 1.019)	(0.994 - 1.000)	(0.981 - 1.019)
Full-service Restaurants	0.976	1.017***	0.973

	(0.920 - 1.034)	(1.006 - 1.027)	(0.918 - 1.032)
Local and Non-chain Restaurants	0.998	0.995***	0.998
	(0.989 - 1.006)	(0.994 - 0.996)	(0.990 - 1.007)
Mediator			
Physical Activity Level			
Physically Active	--	--	0.731***
			(0.623 - 0.858)
Moderately Active	--	--	0.845**
			(0.729 - 0.978)
Inactive (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.265***	--	1.265***
	(1.170 - 1.368)		(1.170 - 1.367)
Age^2	0.999***	--	0.999***
	(0.998 - 0.999)		(0.998 - 0.999)
Gender			
Female	0.542***	--	0.536***
	(0.481 - 0.611)		(0.475 - 0.604)
Male (ref)	--	--	--
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	0.732	--	0.718
	(0.428 - 1.252)		(0.420 - 1.227)
Length of Residency: +10 years	0.823*	--	0.816*
	(0.657 - 1.030)		(0.653 - 1.021)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.186	--	1.187
	(0.954 - 1.474)		(0.956 - 1.474)
Widowed/Separated/ Divorced	1.195	--	1.201*
	(0.961 - 1.486)		(0.966 - 1.493)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.85	--	0.874
	(0.692 - 1.044)		(0.714 - 1.071)
Incomplete Postsecondary Education	0.855	--	0.867
	(0.659 - 1.108)		(0.670 - 1.120)
High School Diploma	0.812*	--	0.820*
	(0.641 - 1.029)		(0.648 - 1.038)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.687***	--	0.703***
	(0.547 - 0.864)		(0.559 - 0.885)
Quintile 4	0.693***	--	0.704***
	(0.560 - 0.858)		(0.569 - 0.871)
Quintile 3	0.820**	--	0.828**
	(0.683 - 0.984)		(0.689 - 0.993)
Quintile 2	0.895	--	0.904
	(0.727 - 1.103)		(0.734 - 1.114)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.001	--	1.001
	(0.997 - 1.006)		(0.996 - 1.005)
Percentage of Low Income	1.001	--	1.001
	(0.987 - 1.015)		(0.987 - 1.015)

Percentage of High School Education	1.004 (0.997 - 1.012)	--	1.004 (0.997 - 1.011)
Percentage of Driving to Work	0.995 (0.987 - 1.003)	--	0.995 (0.987 - 1.003)
Population Density	1.000* (1.000 - 1.000)	--	1.000* (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.755*** (0.643 - 0.885)	--	0.773*** (0.658 - 0.907)
Occasionally Drinker	1.062 (0.897 - 1.257)	--	1.059 (0.895 - 1.254)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	1.522*** (1.203 - 1.927)	--	1.468*** (1.164 - 1.850)
Occasional Smoker	1.273 (0.930 - 1.741)	--	1.26 (0.921 - 1.725)
Former Smoker	1.431*** (1.222 - 1.676)	--	1.435*** (1.225 - 1.680)
Never Smoker (ref)	--	--	--

Table F.3 Physical Activity Level Baron and Kenny Mediation Analysis: Hypertension -- Overall

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.024 (0.975 - 1.076)	1 (0.993 - 1.024)	1.023 (0.974 - 1.075)
Intermediate Grocery Stores	0.998 (0.978 - 1.019)	1.011*** (1.004 - 1.018)	0.997 (0.977 - 1.018)
Small Grocery and Convenience Stores	1.013* (0.998 - 1.027)	1.013*** (1.009 - 1.017)	1.011 (0.996 - 1.025)
Fast-food Restaurants	0.994 (0.985 - 1.003)	0.997** (0.994 - 1.000)	0.995 (0.986 - 1.004)
Full-service Restaurants	1.016 (0.986 - 1.048)	1.017*** (1.006 - 1.027)	1.013 (0.983 - 1.044)
Local and Non-chain Restaurants	0.999 (0.995 - 1.003)	0.995*** (0.994 - 0.996)	0.999 (0.995 - 1.004)
Mediator			
Physical Activity Level			
Physically Active	--	--	0.695*** (0.642 - 0.753)
Moderately Active	--	--	0.896*** (0.833 - 0.963)
Inactive (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.207*** (1.164 - 1.252)	--	1.206*** (1.163 - 1.251)
Age^2	0.999*** (0.999 - 0.999)	--	0.999*** (0.999 - 0.999)
Gender			
Female	0.876*** (0.823 - 0.932)	--	0.864*** (0.812 - 0.919)

Male (ref)	--	--	--
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.087 (0.850 - 1.390)	--	1.061 (0.828 - 1.358)
Length of Residency: +10 years	0.987 (0.901 - 1.080)	--	0.978 (0.894 - 1.071)
Canadian born (ref)	--	--	--
Marital Status			
Married	0.948 (0.851 - 1.056)	--	0.947 (0.850 - 1.054)
Widowed/Separated/ Divorced	0.956 (0.851 - 1.073)	--	0.96 (0.856 - 1.077)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.817*** (0.747 - 0.894)	--	0.841*** (0.769 - 0.919)
Incomplete Postsecondary Education	0.923 (0.809 - 1.052)	--	0.933 (0.819 - 1.063)
High School Diploma	0.899** (0.810 - 0.997)	--	0.907* (0.818 - 1.007)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.868** (0.772 - 0.976)	--	0.889** (0.790 - 0.999)
Quintile 4	0.856*** (0.770 - 0.952)	--	0.867*** (0.780 - 0.965)
Quintile 3	0.837*** (0.757 - 0.926)	--	0.842*** (0.762 - 0.931)
Quintile 2	0.936 (0.853 - 1.028)	--	0.943 (0.859 - 1.035)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.002** (1.000 - 1.004)	--	1.002* (1.000 - 1.004)
Percentage of Low Income	0.996 (0.989 - 1.003)	--	0.996 (0.989 - 1.003)
Percentage of High School Education	1.007*** (1.002 - 1.011)	--	1.006*** (1.002 - 1.011)
Percentage of Driving to Work	1.004* (0.999 - 1.009)	--	1.004 (0.999 - 1.008)
Population Density	1 (1.000 - 1.000)	--	1 (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.886*** (0.816 - 0.962)	--	0.908** (0.837 - 0.986)
Occasionally Drinker	1.023 (0.930 - 1.127)	--	1.023 (0.929 - 1.126)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.935 (0.839 - 1.043)	--	0.902* (0.810 - 1.006)
Occasional Smoker	0.821** (0.691 - 0.977)	--	0.818** (0.690 - 0.971)
Former Smoker	0.95	--	0.953

	(0.881 - 1.024)		(0.885 - 1.027)
Never Smoker (ref)	--	--	--

Table F.4 Physical Activity Level Baron and Kenny Mediation Analysis: Type II Diabetes -- Male

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.044	1.029**	1.04
	(0.920 - 1.184)	(1.005 - 1.053)	(0.916 - 1.181)
Intermediate Grocery Stores	1.012	1.014***	1.011
	(0.951 - 1.077)	(1.004 - 1.024)	(0.950 - 1.076)
Small Grocery and Convenience Stores	1.027	1.012***	1.024
	(0.995 - 1.060)	(1.006 - 1.018)	(0.992 - 1.058)
Fast-food Restaurants	1.012	0.997	1.011
	(0.990 - 1.033)	(0.992 - 1.001)	(0.990 - 1.033)
Full-service Restaurants	1.024	1.022***	1.021
	(0.954 - 1.098)	(1.007 - 1.038)	(0.951 - 1.096)
Local and Non-chain Restaurants	0.99	0.996***	0.991
	(0.979 - 1.002)	(0.994 - 0.997)	(0.979 - 1.003)
Mediator			
Physical Activity Level			
Physically Active	--	--	0.632***
			(0.518 - 0.771)
Moderately Active	--	--	0.866
			(0.729 - 1.030)
Inactive (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.328***	--	1.324***
	(1.223 - 1.443)		(1.219 - 1.438)
Age^2	0.998***	--	0.998***
	(0.997 - 0.999)		(0.997 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.536**	--	1.487**
	(1.054 - 2.237)		(1.024 - 2.160)
Length of Residency: +10 years	1.144	--	1.13
	(0.951 - 1.376)		(0.941 - 1.357)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.04	--	1.038
	(0.829 - 1.305)		(0.826 - 1.303)
Widowed/Separated/ Divorced	0.886	--	0.884
	(0.685 - 1.145)		(0.684 - 1.143)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.819**	--	0.851*
	(0.681 - 0.985)		(0.708 - 1.023)
Incomplete Postsecondary Education	1.191	--	1.212
	(0.899 - 1.578)		(0.917 - 1.602)
High School Diploma	1.044	--	1.058
	(0.821 - 1.327)		(0.833 - 1.344)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.704***	--	0.723**

	(0.545 - 0.910)		(0.560 - 0.934)
Quintile 4	0.808*	--	0.824
	(0.637 - 1.026)		(0.650 - 1.046)
Quintile 3	0.747**	--	0.754**
	(0.593 - 0.940)		(0.599 - 0.950)
Quintile 2	0.904	--	0.92
	(0.721 - 1.134)		(0.734 - 1.153)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.006***	--	1.005**
	(1.002 - 1.010)		(1.001 - 1.010)
Percentage of Low Income	1.004	--	1.005
	(0.988 - 1.021)		(0.989 - 1.022)
Percentage of High School Education	1.009**	--	1.008*
	(1.000 - 1.019)		(0.999 - 1.017)
Percentage of Driving to Work	1.002	--	1.002
	(0.992 - 1.013)		(0.991 - 1.013)
Population Density	1	--	1
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.575***	--	0.589***
	(0.478 - 0.691)		(0.490 - 0.707)
Occasionally Drinker	0.965	--	0.957
	(0.787 - 1.184)		(0.781 - 1.173)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.829	--	0.786*
	(0.646 - 1.064)		(0.613 - 1.008)
Occasional Smoker	0.709	--	0.698
	(0.426 - 1.180)		(0.424 - 1.151)
Former Smoker	1.014	--	1.006
	(0.836 - 1.230)		(0.830 - 1.220)
Never Smoker (ref)	--	--	--

Table F.5 Physical Activity Level Baron and Kenny Mediation Analysis: Cardiovascular Disease -- Male

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.127*	1.029**	1.125
	(0.978 - 1.300)	(1.005 - 1.053)	(0.975 - 1.296)
Intermediate Grocery Stores	0.955	1.014***	0.955
	(0.892 - 1.022)	(1.004 - 1.024)	(0.893 - 1.021)
Small Grocery and Convenience Stores	1.035*	1.012***	1.033*
	(0.996 - 1.075)	(1.006 - 1.018)	(0.994 - 1.073)
Fast-food Restaurants	0.992	0.997	0.992
	(0.966 - 1.019)	(0.992 - 1.001)	(0.966 - 1.019)
Full-service Restaurants	0.96	1.022***	0.957
	(0.886 - 1.039)	(1.007 - 1.038)	(0.884 - 1.037)
Local and Non-chain Restaurants	1.001	0.996***	1.001
	(0.989 - 1.012)	(0.994 - 0.997)	(0.990 - 1.013)
Mediator			
Physical Activity Level			

Physically Active	--	--	0.747*** (0.611 - 0.913)
Moderately Active	--	--	0.886 (0.734 - 1.070)
Inactive (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.391*** (1.257 - 1.539)	--	1.388*** (1.255 - 1.534)
Age^2	0.998*** (0.997 - 0.999)	--	0.998*** (0.997 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	0.572 (0.289 - 1.133)	--	0.561* (0.284 - 1.108)
Length of Residency: +10 years	0.864 (0.647 - 1.154)	--	0.855 (0.642 - 1.139)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.172 (0.908 - 1.514)	--	1.173 (0.910 - 1.513)
Widowed/Separated/ Divorced	1.064 (0.829 - 1.367)	--	1.066 (0.830 - 1.369)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.82 (0.619 - 1.088)	--	0.843 (0.639 - 1.112)
Incomplete Postsecondary Education	0.951 (0.673 - 1.343)	--	0.96 (0.682 - 1.351)
High School Diploma	0.713** (0.509 - 0.998)	--	0.719* (0.515 - 1.004)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.794 (0.590 - 1.067)	--	0.805 (0.599 - 1.084)
Quintile 4	0.788 (0.593 - 1.048)	--	0.798 (0.600 - 1.062)
Quintile 3	0.953 (0.745 - 1.218)	--	0.958 (0.750 - 1.224)
Quintile 2	0.972 (0.710 - 1.331)	--	0.983 (0.718 - 1.344)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.004 (0.998 - 1.009)	--	1.003 (0.998 - 1.009)
Percentage of Low Income	0.996 (0.977 - 1.016)	--	0.997 (0.977 - 1.016)
Percentage of High School Education	1.006 (0.998 - 1.015)	--	1.006 (0.997 - 1.014)
Percentage of Driving to Work	0.989** (0.979 - 0.999)	--	0.989** (0.979 - 0.998)
Population Density	1.000** (1.000 - 1.000)	--	1.000** (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.832* (0.681 - 1.017)	--	0.848 (0.694 - 1.036)

Occasionally Drinker	1.035	--	1.029
	(0.808 - 1.324)		(0.805 - 1.317)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	1.428**	--	1.371*
	(1.013 - 2.011)		(0.980 - 1.917)
Occasional Smoker	1.122	--	1.105
	(0.739 - 1.702)		(0.728 - 1.678)
Former Smoker	1.444***	--	1.438***
	(1.153 - 1.809)		(1.148 - 1.802)
Never Smoker (ref)	--	--	--

Table F.6 Physical Activity Level Baron and Kenny Mediation Analysis: Hypertension -- Male

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.037	1.029**	1.032
	(0.960 - 1.120)	(1.005 - 1.053)	(0.956 - 1.115)
Intermediate Grocery Stores	0.978	1.014***	0.977
	(0.948 - 1.008)	(1.004 - 1.024)	(0.948 - 1.008)
Small Grocery and Convenience Stores	1.013	1.012***	1.011
	(0.992 - 1.034)	(1.006 - 1.018)	(0.990 - 1.032)
Fast-food Restaurants	0.992	0.997	0.993
	(0.979 - 1.006)	(0.992 - 1.001)	(0.979 - 1.006)
Full-service Restaurants	1.019	1.022***	1.015
	(0.975 - 1.064)	(1.007 - 1.038)	(0.972 - 1.060)
Local and Non-chain Restaurants	1.003	0.996***	1.003
	(0.997 - 1.009)	(0.994 - 0.997)	(0.997 - 1.009)
Mediator			
Physical Activity Level			
Physically Active	--	--	0.715***
			(0.639 - 0.800)
Moderately Active	--	--	0.876**
			(0.790 - 0.971)
Inactive (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.211***	--	1.208***
	(1.153 - 1.273)		(1.150 - 1.269)
Age^2	0.999***	--	0.999***
	(0.998 - 0.999)		(0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.063	--	1.034
	(0.761 - 1.485)		(0.738 - 1.448)
Length of Residency: +10 years	0.959	--	0.947
	(0.841 - 1.093)		(0.831 - 1.079)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.039	--	1.037
	(0.910 - 1.187)		(0.910 - 1.183)
Widowed/Separated/ Divorced	0.981	--	0.984
	(0.847 - 1.135)		(0.851 - 1.137)
Single (ref)	--	--	--
Education Level			

Completed Postsecondary Education	0.816*** (0.713 - 0.935)	--	0.843** (0.737 - 0.963)
Incomplete Postsecondary Education	0.969 (0.804 - 1.169)	--	0.984 (0.817 - 1.184)
High School Diploma	0.864* (0.735 - 1.014)	--	0.873* (0.745 - 1.024)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.963 (0.821 - 1.128)	--	0.982 (0.838 - 1.152)
Quintile 4	0.902 (0.776 - 1.047)	--	0.915 (0.787 - 1.064)
Quintile 3	0.885 (0.756 - 1.037)	--	0.892 (0.762 - 1.045)
Quintile 2	1.039 (0.896 - 1.205)	--	1.052 (0.907 - 1.220)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.003* (1.000 - 1.006)	--	1.002 (0.999 - 1.005)
Percentage of Low Income	0.996 (0.986 - 1.006)	--	0.996 (0.986 - 1.006)
Percentage of High School Education	1.008** (1.001 - 1.014)	--	1.007** (1.000 - 1.014)
Percentage of Driving to Work	1.005 (0.998 - 1.012)	--	1.005 (0.998 - 1.012)
Population Density	1 (1.000 - 1.000)	--	1 (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.954 (0.851 - 1.070)	--	0.972 (0.867 - 1.090)
Occasionally Drinker	1.011 (0.868 - 1.177)	--	1.007 (0.866 - 1.172)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.962 (0.816 - 1.135)	--	0.916 (0.779 - 1.077)
Occasional Smoker	0.845 (0.656 - 1.089)	--	0.834 (0.649 - 1.071)
Former Smoker	0.992 (0.885 - 1.112)	--	0.983 (0.878 - 1.101)
Never Smoker (ref)	--	--	--

Table F.7 Physical Activity Level Baron and Kenny Mediation Analysis: Type II Diabetes -- Female

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	0.981 (0.868 - 1.108)	0.989 (0.970 - 1.009)	0.982 (0.870 - 1.109)
Intermediate Grocery Stores	1.061* (0.994 - 1.132)	1.007* (0.999 - 1.016)	1.059* (0.994 - 1.128)
Small Grocery and Convenience Stores	1.03 (0.990 - 1.071)	1.014*** (1.009 - 1.019)	1.024 (0.985 - 1.065)

Fast-food Restaurants	1.034***	0.997*	1.035***
	(1.014 - 1.055)	(0.993 - 1.001)	(1.015 - 1.055)
Full-service Restaurants	0.982	1.011*	0.977
	(0.916 - 1.052)	(0.998 - 1.025)	(0.911 - 1.048)
Local and Non-chain Restaurants	0.976***	0.995***	0.977***
	(0.964 - 0.988)	(0.993 - 0.997)	(0.965 - 0.989)
Mediator			
Physical Activity Level			
Physically Active	--	--	0.519***
			(0.411 - 0.657)
Moderately Active	--	--	0.677***
			(0.557 - 0.822)
Inactive (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.331***	--	1.335***
	(1.209 - 1.466)		(1.212 - 1.470)
Age^2	0.998***	--	0.998***
	(0.997 - 0.999)		(0.997 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.191	--	1.157
	(0.625 - 2.270)		(0.608 - 2.201)
Length of Residency: +10 years	1.209*	--	1.198*
	(0.975 - 1.499)		(0.967 - 1.485)
Canadian born (ref)	--	--	--
Marital Status			
Married	0.590***	--	0.588***
	(0.429 - 0.812)		(0.430 - 0.803)
Widowed/Separated/ Divorced	0.652***	--	0.659***
	(0.477 - 0.893)		(0.485 - 0.896)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.753***		0.798**
	(0.610 - 0.931)	--	(0.643 - 0.991)
Incomplete Postsecondary Education	0.691**		0.711**
	(0.494 - 0.966)	--	(0.508 - 0.995)
High School Diploma	0.849		0.867
	(0.665 - 1.082)	--	(0.681 - 1.105)
Less than High School (ref)	--		--
Income Quintile			
Quintile 5	0.754	--	0.799
	(0.516 - 1.104)		(0.549 - 1.164)
Quintile 4	0.689***	--	0.708***
	(0.531 - 0.895)		(0.546 - 0.918)
Quintile 3	0.979	--	0.994
	(0.765 - 1.255)		(0.777 - 1.272)
Quintile 2	0.753**	--	0.754**
	(0.605 - 0.937)		(0.607 - 0.938)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.004	--	1.003
	(0.998 - 1.010)		(0.998 - 1.009)
Percentage of Low Income	1.01	--	1.011
	(0.992 - 1.030)		(0.992 - 1.030)
Percentage of High School Education	1.016***	--	1.016***
	(1.005 - 1.027)		(1.005 - 1.027)

Percentage of Driving to Work	1.004 (0.991 - 1.017)	--	1.004 (0.991 - 1.017)
Population Density	1 (1.000 - 1.000)	--	1 (1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.464*** (0.376 - 0.572)	--	0.491*** (0.398 - 0.606)
Occasionally Drinker	0.972 (0.777 - 1.215)	--	0.97 (0.779 - 1.208)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	1.007 (0.787 - 1.289)	--	0.972 (0.759 - 1.244)
Occasional Smoker	0.805 (0.442 - 1.464)	--	0.81 (0.444 - 1.478)
Former Smoker	1.038 (0.881 - 1.222)	--	1.062 (0.902 - 1.249)
Never Smoker (ref)	--	--	--

Table F.8 Physical Activity Level Baron and Kenny Mediation Analysis: Cardiovascular Disease -- Female

Variables	Step 1	Step 2	Step 3
	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.008 (0.877 - 1.159)	0.989 (0.970 - 1.009)	1.01 (0.879 - 1.160)
Intermediate Grocery Stores	1.022 (0.967 - 1.081)	1.007* (0.999 - 1.016)	1.022 (0.967 - 1.080)
Small Grocery and Convenience Stores	0.994 (0.959 - 1.031)	1.014*** (1.009 - 1.019)	0.991 (0.956 - 1.028)
Fast-food Restaurants	1.011 (0.987 - 1.036)	0.997* (0.993 - 1.001)	1.012 (0.988 - 1.036)
Full-service Restaurants	0.994 (0.914 - 1.081)	1.011* (0.998 - 1.025)	0.992 (0.912 - 1.079)
Local and Non-chain Restaurants	0.993 (0.982 - 1.005)	0.995*** (0.993 - 0.997)	0.994 (0.982 - 1.006)
Mediator			
Physical Activity Level			
Physically Active	--	--	0.708*** (0.548 - 0.915)
Moderately Active	--	--	0.794* (0.631 - 1.000)
Inactive (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.114* (0.995 - 1.248)	--	1.119* (0.998 - 1.254)
Age^2	1 (0.999 - 1.001)	--	1 (0.999 - 1.001)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.145 (0.476 - 2.758)	--	1.118 (0.463 - 2.702)
Length of Residency: +10 years	0.716**	--	0.716**

	(0.543 - 0.944)		(0.542 - 0.946)
Canadian born (ref)	--	--	--
Marital Status			
Married	1.152	--	1.153
	(0.781 - 1.700)		(0.780 - 1.705)
Widowed/Separated/ Divorced	1.244	--	1.26
	(0.842 - 1.839)		(0.850 - 1.866)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.912	--	0.939
	(0.722 - 1.153)		(0.744 - 1.186)
Incomplete Postsecondary Education	0.727*	--	0.741*
	(0.521 - 1.014)		(0.532 - 1.031)
High School Diploma	1.001	--	1.014
	(0.763 - 1.314)		(0.772 - 1.331)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.489***	--	0.506***
	(0.325 - 0.736)		(0.337 - 0.761)
Quintile 4	0.570***	--	0.580***
	(0.407 - 0.798)		(0.414 - 0.811)
Quintile 3	0.664***	--	0.673***
	(0.504 - 0.875)		(0.511 - 0.887)
Quintile 2	0.826	--	0.828
	(0.656 - 1.040)		(0.659 - 1.042)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	0.996	--	0.996
	(0.989 - 1.003)		(0.989 - 1.003)
Percentage of Low Income	1.008	--	1.008
	(0.989 - 1.028)		(0.989 - 1.027)
Percentage of High School Education	1.001	--	1.001
	(0.988 - 1.013)		(0.988 - 1.013)
Percentage of Driving to Work	1.006	--	1.005
	(0.991 - 1.021)		(0.991 - 1.020)
Population Density	1	--	1
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.645***	--	0.666***
	(0.502 - 0.829)		(0.517 - 0.856)
Occasionally Drinker	1.066	--	1.067
	(0.845 - 1.344)		(0.846 - 1.346)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	1.695***	--	1.648***
	(1.281 - 2.243)		(1.246 - 2.180)
Occasional Smoker	1.547*	--	1.547*
	(0.961 - 2.490)		(0.960 - 2.493)
Former Smoker	1.352***	--	1.367***
	(1.084 - 1.685)		(1.096 - 1.705)
Never Smoker (ref)	--	--	--

Table F.9 Physical Activity Level Baron and Kenny Mediation Analysis: Hypertension -- Female

Variables	Step 1	Step 2	Step 3

	Relative Prevalence Ratios (95% Confidence Intervals) *** p<0.01, ** p<0.05, * p<0.1		
Density Measures			
Supermarkets and Large Grocery Stores	1.009 (0.950 - 1.072)	0.989 (0.970 - 1.009)	1.011 (0.952 - 1.073)
Intermediate Grocery Stores	1.022 (0.995 - 1.049)	1.007* (0.999 - 1.016)	1.021 (0.994 - 1.048)
Small Grocery and Convenience Stores	1.012 (0.994 - 1.031)	1.014*** (1.009 - 1.019)	1.01 (0.992 - 1.028)
Fast-food Restaurants	0.997 (0.985 - 1.008)	0.997* (0.993 - 1.001)	0.997 (0.986 - 1.008)
Full-service Restaurants	1.013 (0.972 - 1.055)	1.011* (0.998 - 1.025)	1.01 (0.970 - 1.053)
Local and Non-chain Restaurants	0.995* (0.989 - 1.000)	0.995*** (0.993 - 0.997)	0.995 (0.990 - 1.001)
Mediator			
Physical Activity Level			
Physically Active	--	--	0.672*** (0.602 - 0.751)
Moderately Active	--	--	0.932 (0.845 - 1.029)
Inactive (ref)	--	--	--
Individual Level Confounders			
Age			
Age	1.218*** (1.153 - 1.287)	--	1.220*** (1.155 - 1.288)
Age^2	0.999*** (0.998 - 0.999)	--	0.999*** (0.998 - 0.999)
Immigration Status/Length of Residency			
Length of Residency: 1 to 10 years	1.163 (0.817 - 1.655)	--	1.146 (0.806 - 1.631)
Length of Residency: +10 years	1.032 (0.919 - 1.158)	--	1.031 (0.918 - 1.158)
Canadian born (ref)	--	--	--
Marital Status			
Married	0.873 (0.742 - 1.028)	--	0.873* (0.742 - 1.026)
Widowed/Separated/ Divorced	0.888 (0.751 - 1.051)	--	0.896 (0.758 - 1.059)
Single (ref)	--	--	--
Education Level			
Completed Postsecondary Education	0.841*** (0.749 - 0.943)	--	0.859*** (0.765 - 0.964)
Incomplete Postsecondary Education	0.892 (0.745 - 1.067)	--	0.897 (0.750 - 1.072)
High School Diploma	0.943 (0.829 - 1.073)	--	0.95 (0.835 - 1.081)
Less than High School (ref)	--	--	--
Income Quintile			
Quintile 5	0.764*** (0.629 - 0.926)	--	0.786** (0.648 - 0.954)
Quintile 4	0.830** (0.709 - 0.973)	--	0.840** (0.717 - 0.984)
Quintile 3	0.817*** (0.722 - 0.926)	--	0.822*** (0.726 - 0.930)
Quintile 2	0.869**	--	0.871**

	(0.775 - 0.976)		(0.776 - 0.978)
Quintile 1 (ref)	--	--	--
Neighbourhood Level Covariates			
Percentage of Visual Minority	1.002	--	1.001
	(0.999 - 1.005)		(0.999 - 1.004)
Percentage of Low Income	0.997	--	0.997
	(0.988 - 1.006)		(0.988 - 1.006)
Percentage of High School Education	1.006**	--	1.006**
	(1.001 - 1.012)		(1.000 - 1.012)
Percentage of Driving to Work	1.003	--	1.002
	(0.997 - 1.009)		(0.996 - 1.008)
Population Density	1	--	1
	(1.000 - 1.000)		(1.000 - 1.000)
Lifestyle Confounder			
Type of Drinker			
Regular Drinker	0.828***	--	0.851***
	(0.738 - 0.929)		(0.760 - 0.954)
Occasionally Drinker	1.028	--	1.029
	(0.909 - 1.161)		(0.911 - 1.163)
Non Drinker (ref)	--	--	--
Smoking Status			
Daily Smoker	0.951	--	0.929
	(0.830 - 1.090)		(0.810 - 1.066)
Occasional Smoker	0.824*	--	0.829*
	(0.661 - 1.027)		(0.667 - 1.030)
Former Smoker	0.953	--	0.966
	(0.860 - 1.056)		(0.872 - 1.070)
Never Smoker (ref)	--	--	--

Appendix G: Names of Food Stores

Table G.1 List of Top 50 Restaurants, Supermarket, and Grocery Stores Retail Chains

Full Service Restaurants	Fast Food Restaurants	Supermarkets and Large Grocery Stores
abc Country Restaurants	2 4 1 Pizza	IGA
Applebee's	A & W	Atlantic Superstore
Au Vieux Duluth	Arby's	Big Bear Food Mart
Casa Grecque	Baskin-Robbins	Bigway
Chicken Chef	Booster Juice	Bonichoix
Chicken Delight	Boston Pizza	Buy-Low Foods
Cora's Breakfast and Lunch	Burger King	CANEX
Crabby Joe's Tap & Grill	Cafe on the Go	Co-op Food Store
Darden Restaurants (Olive Garden, Red Lobster)	Cafe Supreme	Cooper's Foods
Dixie Lee Chicken & Seafood	Coffee Time	Dominion
Earl's Restaurant	Country Style	Farm Boy
Edo Japan	Dairy Queen	Food Basics
Golden Griddle Family Restaurant	Denny's	Foodland
Humpty's Restaurants	Domino's Pizza	Fortinos
Ichiban Sushi	Double Double Pizza & Chicken	Freshmart
Joey's Only Seafood Restaurants	Druxy's Famous Deli Sandwiches	Fruiticana
Jungle Jim's	Dunkin' Donuts	Kin's Farm Market
Kelsey's Neighbourhood Bar & Grill	Extreme Pita	L&M Markets
La Cage Aux Sports	Gino's Pizza	Les Supermarche GP
La Piazzetta	Grinner's Food Systems (Captain Sub, Greco's Pizza)	L'intermarche
Lemongrass	Harvey's	Loblaws/Loblaw Great Food
Les Rotisseries Fusee	Husky Energy Inc. (Husky House Restaurant)	Longo's
Les Rotisseries St-Hubert	Imvescor Restaurants (Pizza Delight, Baton Rouge, Mikes Restaurant, Score Rotisserie)	Lucky Dollar Foods
Lone Star Texas Grill	Le Muffin Plus	Marche Richelieu
Mandarin Restaurant	Les Cafes V.P.	Marche Vegetarien/Les Arpents Verts
Milestone's Grill & Bar	Little Caesars Pizza	Marketplace IGA
Montana's Cookhouse Saloon	Made In Japan (Teriyaki Experience)	Maxi
Moxie's Classic Grill	Manchu WOK	Maxi & Cie
Prime Restaurants (Casey's Bar & Grill, East Side Marios, Darcy McGee Irish Pub, Bier Market)	Mary Brown's Chicken	Metro
Red Robin Restaurant	McDonald's	No Frills
Restaurant Amir	Mr. Sub	Overwaitea Foods

Restaurant Ashton Casse-Croute	MTY Tiki Ming Enterprises (Mrs Vanellis, Panini Pizza, Tiki Ming, Restaurant Sukiyaki, Villa Madina, Croissants Plus, Cultures, Thai Express, Kim Chi House, Koya Japan, Tutti Frutti, Sushi Shop, O'Burger)	Price Chopper
Restaurant Normandin	New Orleans Pizza	Provigo
Restaurant Pacini	New York Fries	Rabba Fine Foods
Restopro (Nickel's Restaurant, Vinnie Gambini's Restaurant, Roaster's Rotisserie)	Pita Pit	Red & White Food Store
Shoeless Joe's	Pizza Pizza	Safeway Canada
SIR Corp (Alice Fazooli's, Canyon Creek, Jack Astor's, Far Niente, Four)	Quizno's Subs	SaveEasy
Smitty's Restaurant	Ricky's Restaurants	Save-On-Foods
St. Louis Bar & Grill	Robin's Donuts	Shop Easy Foods
Sunset Grill	Starbucks	Sobeys
Swiss Chalet	Subway	Super A
Taco Time	The Great Canadian Bagel	Super C
The Firkin Group of Pubs	The Second Cup	SuperValu
The Keg Steakhouse & Bar	Tim Hortons	T&T
The Pantry Restaurant	Timothy's World Coffee	The North West Company
The Pegasus Group (Fox & Fiddle, Miller Tavern, O'Grady Restaurant, Philthy McNasty)	Treats	Thrifty Foods
Tony Roma's	Valentine	Valu-mart
White Spot Restaurant	Van Houtte	Whole Foods Market
Wild Wing	Wendy's	Your Independent Grocer
Wimpy's Diner Restaurant	Yum! Restaurants (KFC, Pizza Hut, Taco Bell)	Zehrs

Curriculum Vitae

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